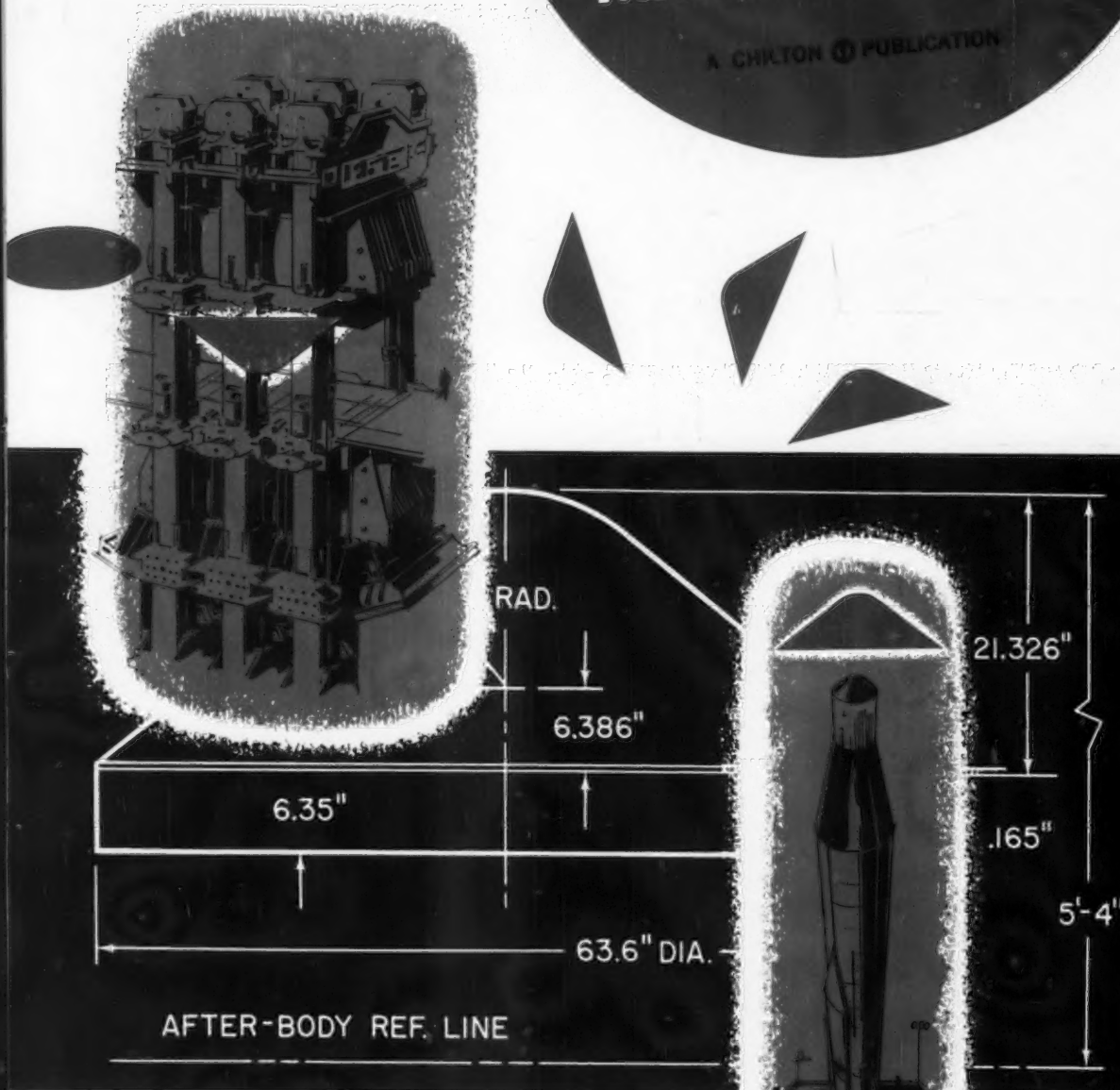
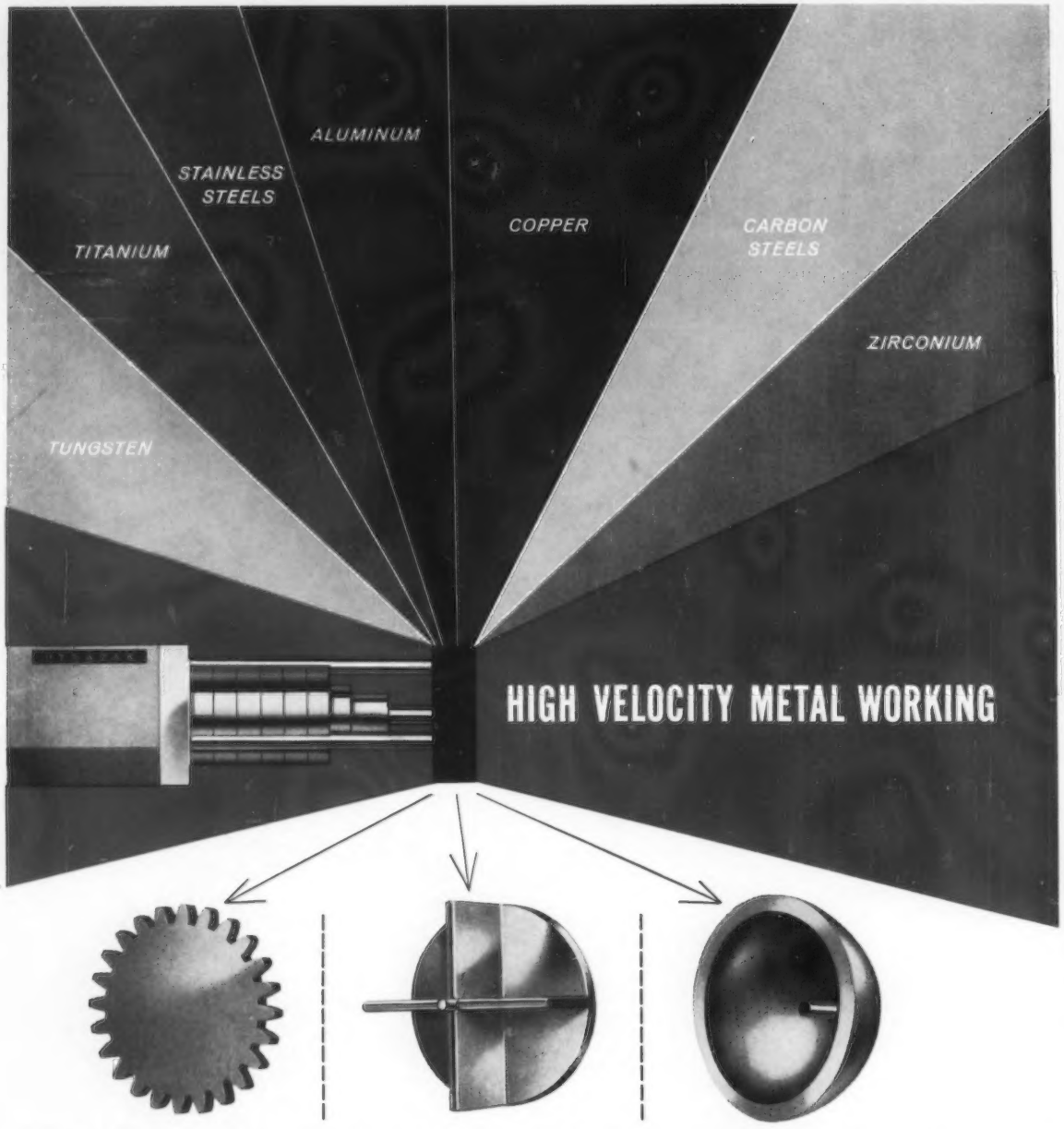
# AIRCRAFT AND MISSILES MANUFACTURING

A CHILTON PUBLICATION

AUGUST 1959




DESIGN PRODUCTION PROCUREMENT



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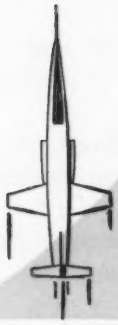

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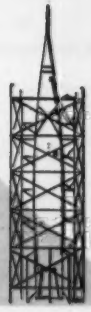

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AIRCRAFT AND MISSILES MANUFACTURING

AUGUST 1959
*volume 2, number 8*
DESIGN
PRODUCTION
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*a Chilton publication*

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## THE COVER STORY

It takes a mighty squeeze to make a heat shield for a mighty missile. The squeeze is provided by the 50,000-ton hydraulic press at Wyman Gordon's Grafton, Mass. plant, to provide copper heat-sink type nose cones for the Atlas ICBM. Starting with 9000-lb, 99.9 per cent copper billets, forged blanks are supplied to General Electric's Missile and Space Vehicle Dept., for machining. Final product is a glittering shield of 1115 lb for Atlas and Thor payloads.

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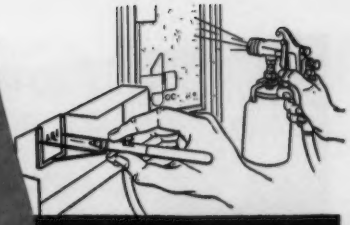

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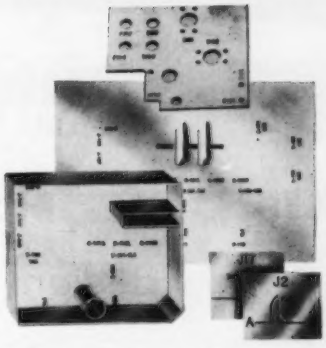

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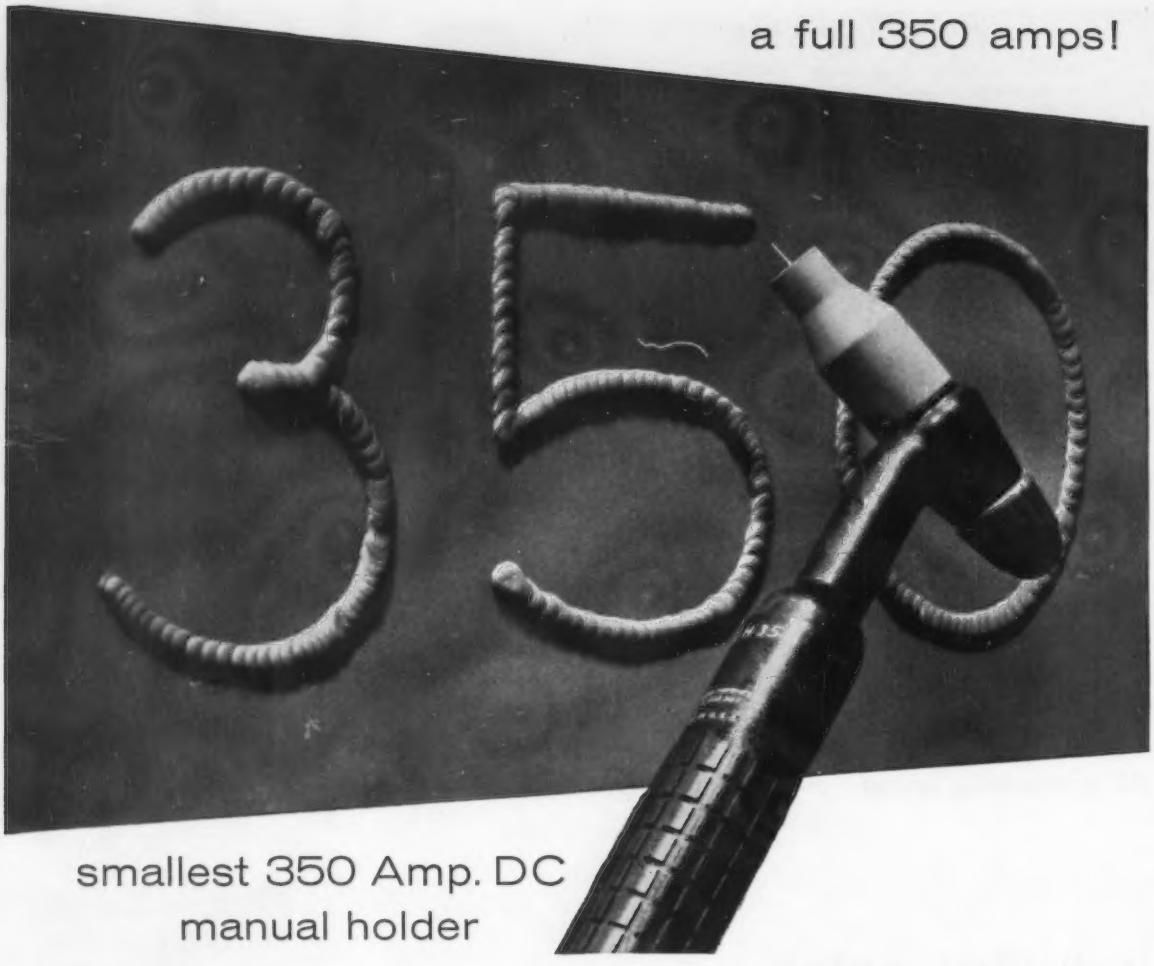


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## technological trend

Where will we be ten years from now? What do we need in terms of aircraft and missile hardware?

In an extremely interesting report, technical committees of the Aerospace Industries Association, have compiled a "shopping list" of scientific achievements needed over the next decade. Here are some of the highlights.

For continuous flight in the atmosphere during the next ten years, aircraft speeds will level off at about Mach 4.

Maximum acceleration in gravitational force units will increase for tactical missile thrust and maneuver loads from 50 to about 80 Gs, and in the case of re-entry vehicles from 150 to 170 Gs. In the late 1960's when a re-entry vehicle might be launched from a satellite, acceleration will approach 200 Gs and more.

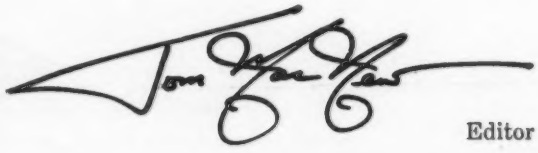
Thrust efficiency of future rocket engines, based upon expected fuel developments, should increase by at least 50 per cent. With free radical and nuclear power plants a 400 per cent increase is possible. It is expected that these systems will replace chemical fuel power plants after 1970.

It is expected that a large number of weldments will be used for structures and the use of high-density metals increase. On the non-metallic side, the report states that silicones will become increasingly important.

High temperature airframes will employ a greater proportion of built-up structure and a reduced amount of integral structure. This is reflected by an increase in the use of sheet material and a reduction in the requirements for cast and wrought forms of material. Brazed and welded honeycomb will be widely used.

Production-wise, it looks like a decade of bonding. Requirements will emphasize the use of ceramic adhesives. Extremely large contoured parts such as wings and fins will be joined with adhesives. Bonding steels will become commonplace. Fabrication techniques must be developed to permit shape-fabrication of high strength steels with yields in excess of 300,000 psi and titanium alloys with strength yields in excess of 200,000 psi.

There will be wider use of ultrasonic and electrical discharge machining. For reliability, test procedures will be recorded on tape to completely automate systems testing. The trend is toward memory drums and storage devices that will be able to compare and make decisions with regard to accumulated test data.



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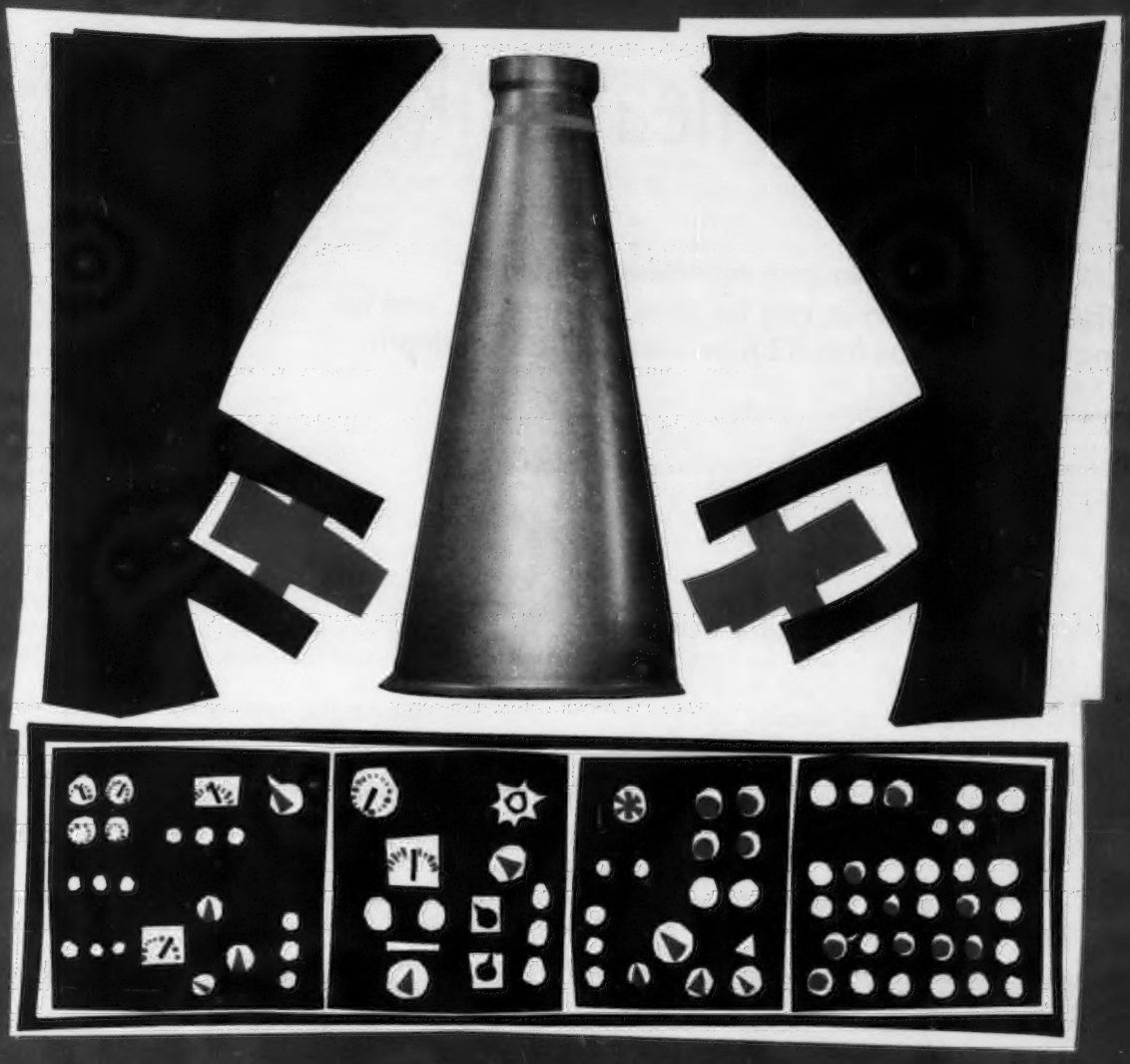

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# HUFFORD

# the copper heat-sink

**Mark II nose cones forged, machined, plated; polished to 12 micro-in. rms for Atlas, 60 micro-in. rms for Thor; 1115-lb cone has 63.6 in. diam, 21-33 in. depth**

by John P. Kushnerick

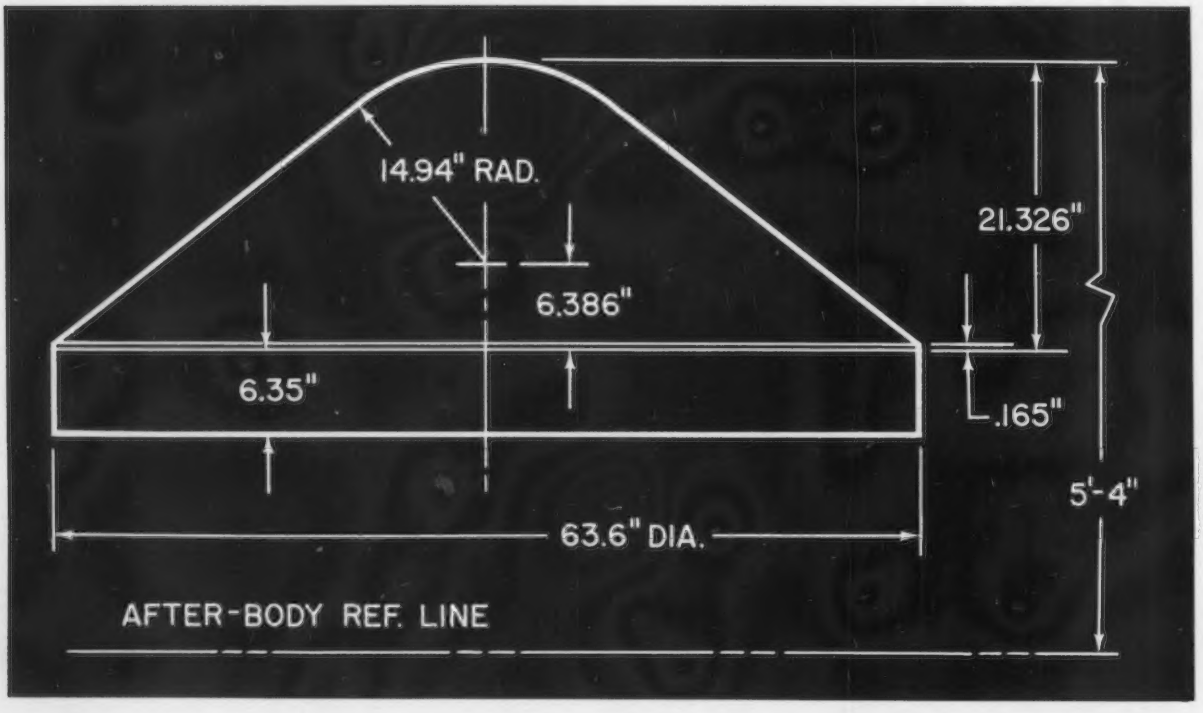
Upfront, where it counts, an 1115-lb copper heat sink protects Atlas and Thor payloads against destructive re-entry heats.

On a 5000 nautical mi ballistic flight, energy content in a re-entering body is equivalent to 10,000 BTU/lb. This is enough heat to reduce any fabricable, structural material to vapor. How then does a low-melting metal like copper do the job?

By making the nose cone blunt, a great deal of the heat will dissipate into a shock wave system in front of the cone. Hence, the heat shield need only handle a fraction of the total heat. This heat is still considerable, however, and at peak

**NOSE CONE SPECIFICATIONS**

**Heat sink cones for Atlas and Thor are made of copper. Atlas receives 12-RMS nickel plate finish, Thor has 60 RMS finish, is only painted.**



areas it exceeds 2000 BTU/ft²/sec. The excellent conductivity of copper allows heat to be carried away from these peak areas and spread rapidly through the entire mass. Since re-entry time does not exceed several tens of seconds, the entire mass is able to soak-up all the heat, (hence "heat sink") and still remain intact.

**HEAT SINK PROPERTIES**

| Material (pure) | Heat required to raise to melt point (BTU/lb) | Conductivity BTU/ft/sec/°R |
|---|---|---|
| Copper | 150 | 0.0632 |
| Aluminum | 280 | 0.0366 |
| Molybdenum | 420 | 0.0235 |
| Tungsten | 770 | 0.0323 |
| Beryllium | 1600 | 0.0255 |
| Graphite | 4100 | 0.0051 |

It can be seen, materials used as heat sinks must possess a happy combination of good conductivity to rapidly distribute local peaks, fairly high melting point, and light weight as not to restrict rocket launch. Copper has these qualities for Thor and Atlas missions.

The following steps are essential in converting a 9000 lb, 99.9-per cent-copper billet into a heat shield.

- Forging to approximate configuration.
- Machining to desired inside and outside dimensions.
- Polishing to smooth finish (Atlas)
- Nickel plating (Atlas), pointing (Thor)

### Forging—One Ton of Chips Eliminated

A 50,000 ton hydraulic press, at Wyman-Gordon Co's Grafton plant, is used for forging the copper nose-cone shapes. Forgings are over 5 ft in diam, about 22 in. deep, and 1¼ in. thick. Except for a small lip, and six lugs near the inside mouth of the cone, both the inside and outside walls of the forging follow a smooth, shallow cone.

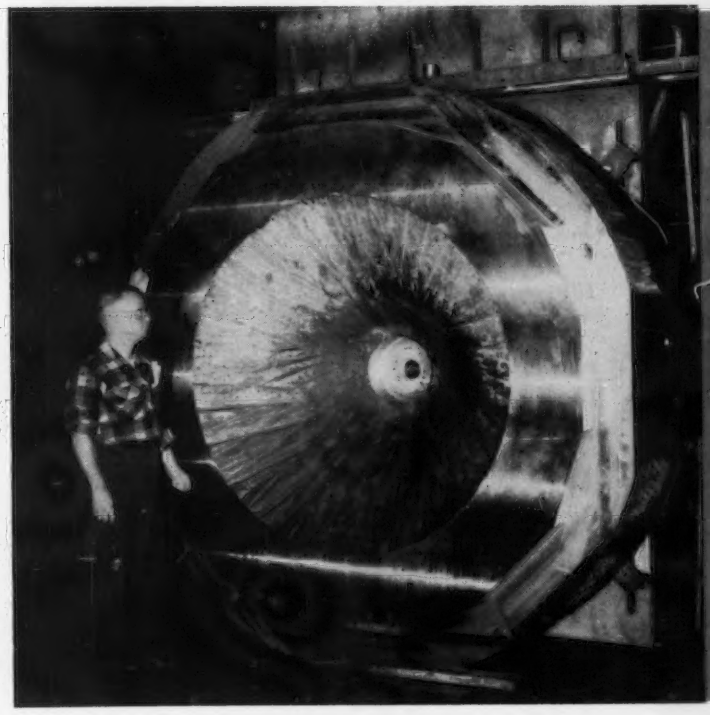
Before General Electric Missiles and Space Vehicles Dept., prime contractor, turned to this one piece forging, over 1 ton of chips was generated in machining nose cone blanks to final dimensions.

Majority of the machining was done on the inside surface while forming the six attach-lugs. Entire inside was machined out about 1½ in. except for a 2-in. circumferential weld. In a second machining operation, portions of this ring were removed leaving only the six lugs. The shape was reduced from 3500 lb to 1115 ± 5 lb during machining.

With the closed die forging process now in use, lugs are part of the shape as it is removed from the die.

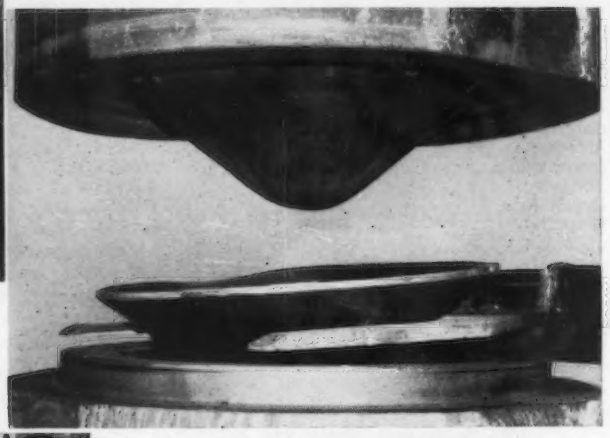
### Forging Steps

Copper billets for the forging are supplied by American Metals Climax Co. and by American Smelting and Refining Co. Largest billet has 28



Female die for closed die forging process was machined from 35 ton piece of tool steel. Male die also weighs about 35 tons.

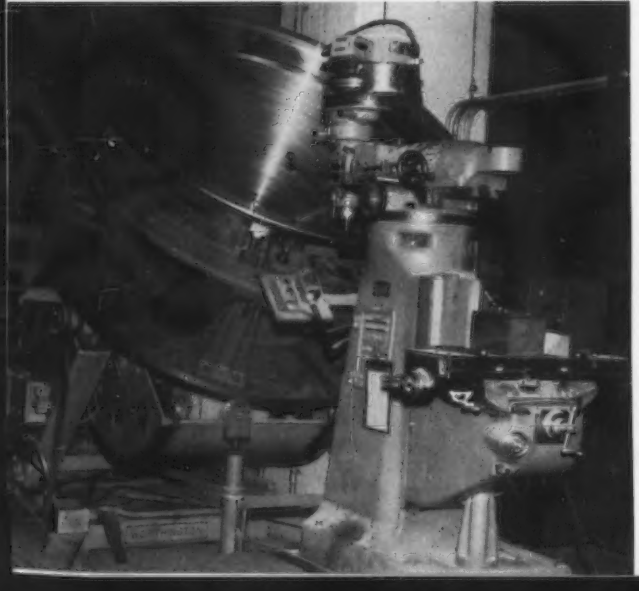
Nose cone forging is done by Wyman-Gordon at Grafton, Mass. 50,000-ton press, product of "heavy press program," is shown with male die being lubricated.



Mobile fork lift is used to remove finished forging from press. Indentation for attaching lugs can be seen at widest part of male die.

Outside diameter of cone is machined on vertical boring mill at General Electric. Coolant is 40 to 1 water and oil emulsion.

Inside surface of copper cone has six lugs for attachment to rest of re-entry body. This machining is done on a converted Bridgeport miller.



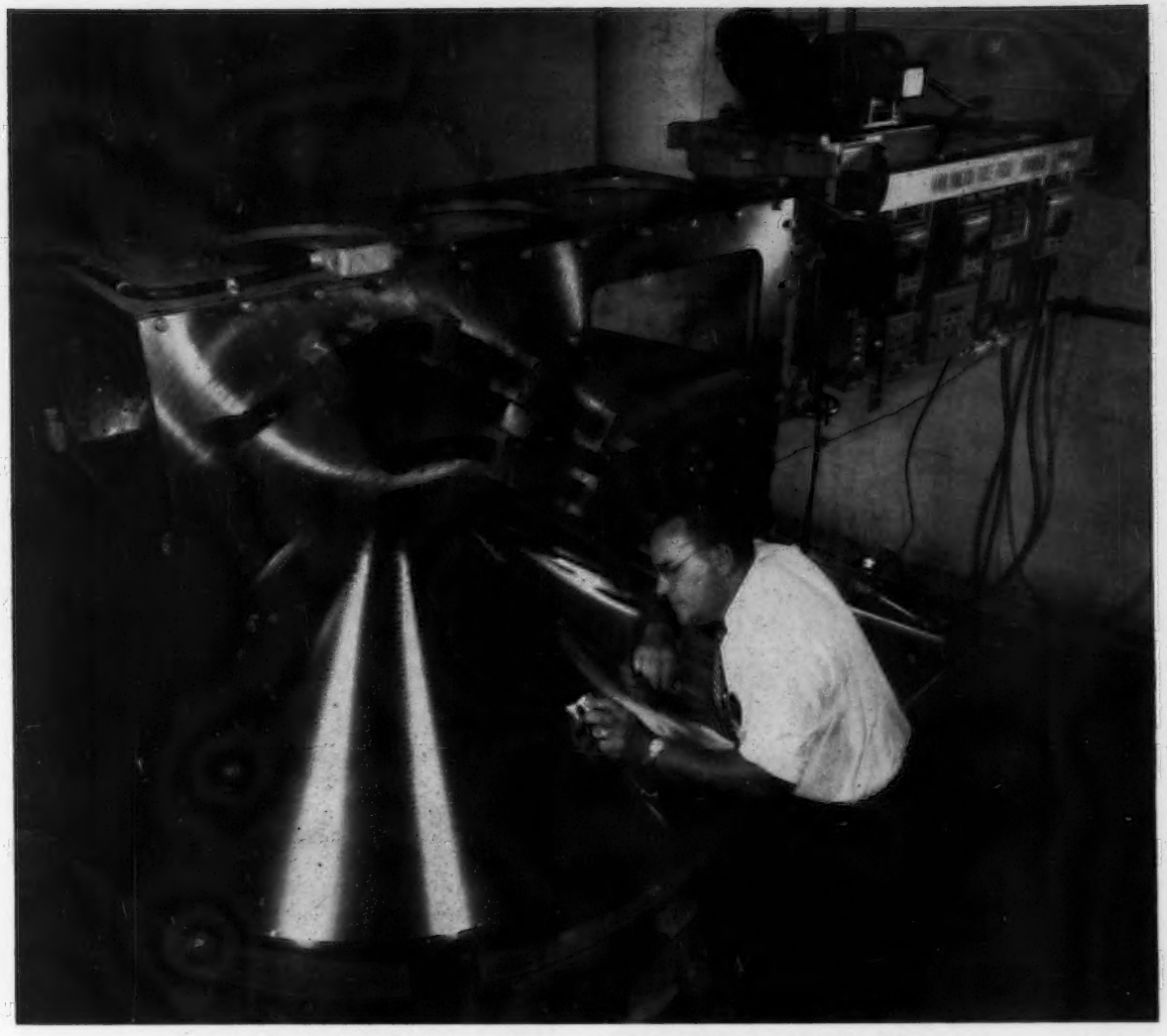
in. diam and weighs 9000 lb. Billet is first sawed to determined length, and examined for casting defects. Defects are removed with a turret lathe.

Lengths are heated for hot upsetting to pancake shape with 30 in. diam and 9 in. thickness in an 18,000 ton closed-die forging press.

This blank is again heat treated and returned hot to the 18,000 ton press for initial forming. A band saw is used to remove excess flash. Ultrasonic inspection is used to determine metallurgical soundness.

Final forming is done in one pass with hot work piece and hot dies in the 50,000 ton closed-die press. Immersion ultrasonic-inspection is effected before shipping.

Wyman-Gordon claims these nose cones are the largest closed die forgings made in this country. The firm also says they represent a forging achievement since grain structure is pre-



**Where 12 microinch finish is desired, machined surface is polished. Belt polisher revolves tangential to cone surface, and is moved hydraulically up and down wall on cam system.**

served and good flow is achieved up walls despite 22 in. cone depth.

### Machining—60 Microinch Finish

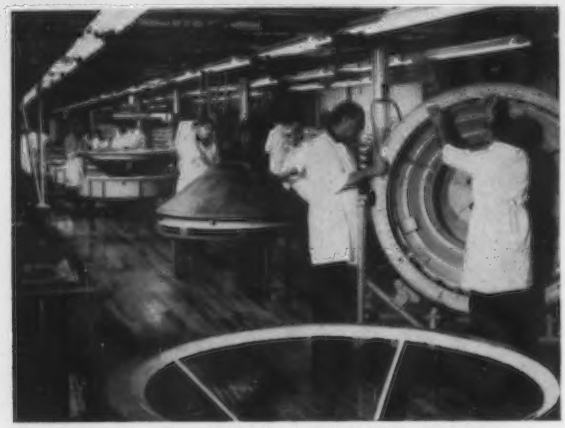
The forged shapes are shipped to GE's Burlington facility for production machining. Some evaluation machining is done at the Philadelphia facility.

Machining is done in three major steps:

- Inside surface, machined on standard vertical boring mill.
- Attachment lugs, machined on GE-converted miller.
- Outside surface, machined on standard vertical boring mill.

MACHINING OF INSIDE SURFACE is done on a Giddings & Lewis boring mill at Burlington, Vt. A second G & L boring mill is used for machining outside surface. The Philadelphia facility is equipped with one G & L and one Bullard. An electronic tracer control manufactured by GE is used on all machines. As the cutting tool moves up the cone, (toward smaller diameter) the tracer control varies the turntable speed to keep sfpm constant somewhere between 450 and 500, and chip control constant at 0.0001 per revolution. A skive miller is used where cone diam drops off to such an extent that sfpm cannot be maintained by rotating the work piece. Restrictions on rotating speeds arise from complex hold-down facilities required for such a large, heavy work piece.

MILLING OF LUGS, which secure heat shield to support assembly for electronic equipment, is done on a converted Bridgeport miller. Machine is essentially a combination of the miller and a welding positioner. Necessity for this machine arose when production was stepped up and the



Various phases of re-entry body fabrication are shown on the production line. Cone shape in center is silicone blanket used behind the copper shield. Fiberglass insulation is also used.

valuable vertical boring mills ($150,000 plus electronic tracer) were being tied up by machining of lugs.

Lugs are then tapped with standard equipment and a Helicoil insert is used to give threads with adequate strength.

MACHINING THE OUTSIDE SURFACE is performed by using the lugs for hold-down. The same machinery and tracer control described in "machining inside surface" are used. All surfaces are machined to a 60 microinch finish. And all dimensions are held to ±0.005 in. A 40 to 1 mixture of water and oil is used as the coolant.

### Polishing

Nose cones for Atlas are polished to a 12 microinch finish using converted machinery. Several machine tool builders were initially approached with the problem and submitted bids almost $20,000 per machine in excess of what was finally achieved by in-house conversion. A conventional radial-drill-press was coupled with an improvised cam-following belt-sander to give initial polish. Final polish is imparted by hand, using jewelers rouge. Polishing-time is six hr per stage.

The effects of surface roughness were unknown for a long time. Telemetry data from test flights now indicate that IRBM re-entry conditions are not severe enough to warrant a 12 microinch finish. The 60 microinch machining finish, with a coat of reflective paint, is therefore adequate for Thor.

### Nickel Plating

When the nose cone slams into the atmosphere on the latter half of an Atlas ballistic flight, the shock-wave boundary layer can become turbulent, instead of remaining laminar. This means the heat which should be absorbed by compressing of air in front of the cone, is actually transmitted to the cone itself. In addition, Atlas 5000 mi flight takes the nose cone into micrometeorite areas, subjects it to conditions where absorbity-to-emissivity ratio must be dealt with longer and gives upwards of a 50-g jolt when hitting the atmosphere. A coat of nickel is applied to the copper cone to assist in handling these conditions.

Plating is done by Bart Manufacturing Co., at Belleville, New Jersey. Special facilities were developed to:

- Handle work pieces up to 1 ton.
- Plate to original 12 microinch finish with up to 0.040 in. deposits.
- Control plating thickness to ±0.001 in.
- Leave static balance intact after plating.
- Retain buoyancy advantage as long as possible while handling nose cones in plating solutions.
- Reclaim copper cones without harming initial finish should nickel plate be rejected. (Hampshire Chemical Co., Providence R. I.

Both Watts and all-sulfate nickel baths were used with acceptable results.

To maintain a wet surface while transfering nose cones from one plating tank to another, acid-rinse was refrigerated. And, cold water was played on all external surfaces while work piece was out of the tank.

Conforming anodes were designed to aid in giving a uniform deposit. A special solution-agitation system was also developed. The problem of edge buildup was handled by using a peripheral plastic shield resembling a picket fence. Variations in picket length, slot-width to picket-width ratio, make adjustments easy.

### Development Justified

Although being rapidly replaced by ablative cones, the costs involved in developing the copper heat sink seem justified.

Tests indicate copper cones will fulfill their mission. They have been instrumental in verifying test cell data and paving the way for the ablative cones. They were the easiest stop-gap at a time when insufficient engineering data existed on reinforced plastics.

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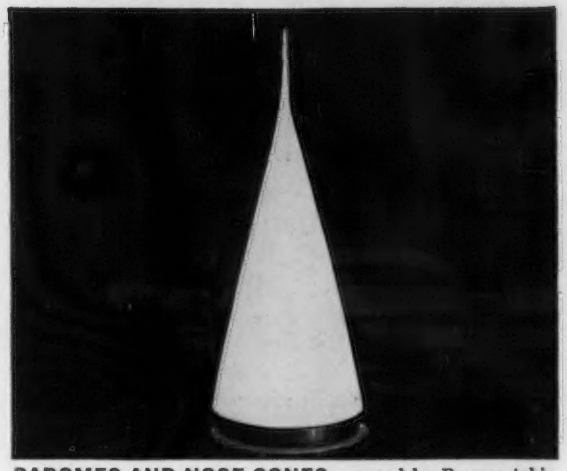
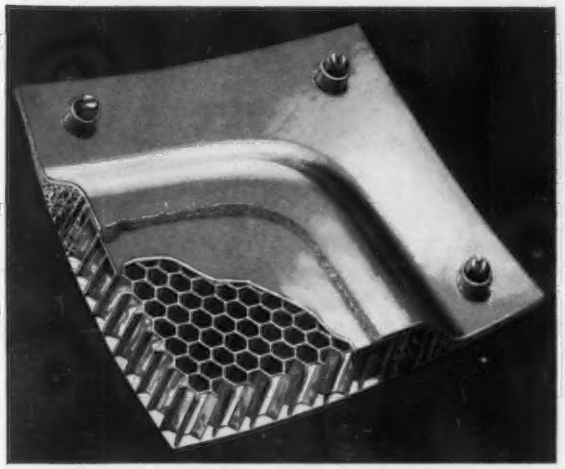
# Brunswick technology leads the way in three critical space-age components

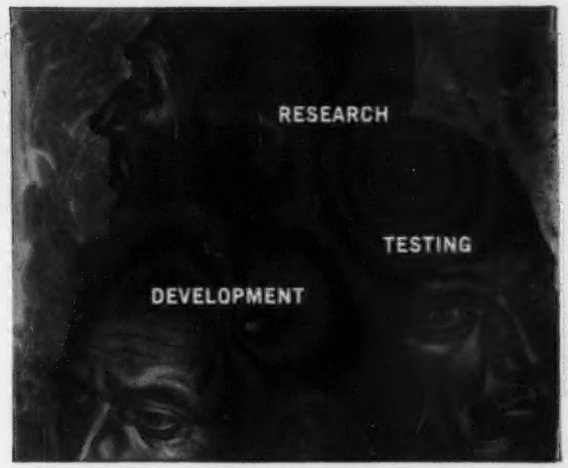
**PRESSURE VESSELS AND MOTOR CASES,** fabricated by Brunswick's exclusive Strickland "B" Process, now have the highest strength-to-weight ratio ever obtained in filament-wound components. Brunswick is *now* producing these virtually leak-proof pressure vessels. Brunswick also fabricates motor cases capable of withstanding extremely high pressures and temperatures.



**RADOMES AND NOSE CONES,** created by Brunswick's outstanding research and development efforts and filament winding process, are being used on supersonic aircraft such as the advanced Convair F-106 and McDonnell F4H, as well as on missiles such as the Boeing Bomarc, Lockheed Q5 and similar missiles. And, of course, Brunswick capabilities include complete electronic design and test facilities.



**HONEYCOMB ASSEMBLIES,** now developed by Brunswick can support two million times their own weight. Brunswick research has created honeycomb assemblies of paper, fiber glass, aluminum and stainless steel as well as conventional forms. Using the most advanced adhesive systems, these assemblies can be formed in compound curvatures with extremely close tolerances.




**RESEARCH, DEVELOPMENT AND TESTING**—carried on by Brunswick teams have contributed heavily to space-age technology . . . most notably in solving problems of increasingly high operating temperatures (600°—4,000°F.) for critical components and new heights in strength-to-weight ratios. For full information on how this leadership can help you, write or call Brunswick today!

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# photoelasticity

## a vital tool in stress analysis, can be used as a rough guide or with quantitative precision

by C. R. Smith, design specialist
Convair-San Diego

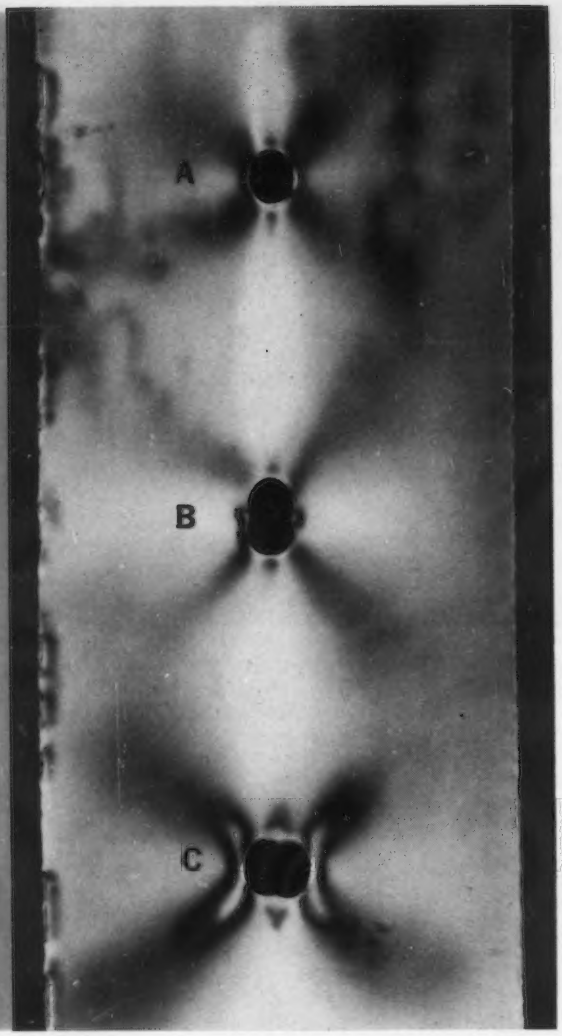



Fig. 1. Typical stress patterns to be expected around drillings. (B) and (C) represent misdrilled holes. (C) is especially undesirable.

What is photoelasticity? Does it take an expert to use it in design?

Photoelasticity involves the use of plastic models for measuring stress distribution by visual observation of light interference fringe patterns set up by polarized light. More simply, one makes a plastic model of the structure to be analyzed. Polarized light is passed through the model. By looking at the model through another polaroid, light fringes come into view which can be interpreted in terms of stress. The patterns change as loads on the model are changed. The exact manner in which these patterns are evaluated is what is usually left to the experts. However, the "not-too-expert" person can judge the relative distribution of stress by using the simple techniques which follow.

### Stresses Using Two Polaroids

Fig. 1 shows the type pattern to expect in a plastic model. The light fringes appear as dark lines, and for the plastic used in this experiment, amount to about 0.050 in./in. strain per fringe. With colored light, interpolation between fringes can be made. Of interest in this figure, is the pattern for three different types of holes: one which is round (A); and two which are oblong, but whose axis are oriented at right angles to each other (B), (C). The oblong holes simulate the case of mis-drilled holes in a structure. Note that the stress for the hole whose axis is normal to the direction of loading (C), is substantially higher than for the other two. Theoretically, the hole oblong in the direction of load does no harm. It could, in fact, be beneficial. This is borne out in this experiment.

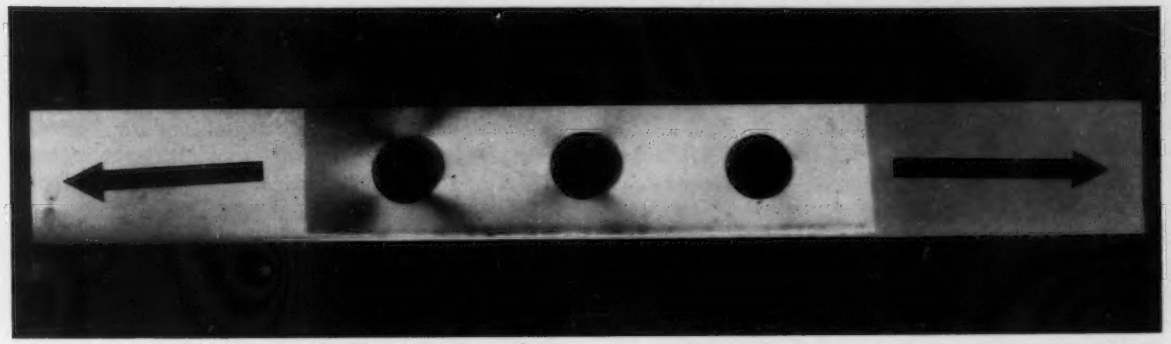


**Fig. 2. Simulated joint shows why failures almost invariably occur along first row of rivets in major structures.**

Fig. 2 shows a riveted joint simulated by fastening a 1-in. wide strip of 0.10 thick vinyl to an 0.20 thick piece of cellulose-acetate with three screw paper fasteners. The model is sandwiched between two polaroid filters as for Fig. 1. This visually demonstrates the difference in load between rivets in a joint. It also shows why fatigue failures in major structures almost invariably occur in the skin along the first row of rivets.

Thus far, models discussed have made use of two sets of polaroids; light has passed through both polaroids and the plastic model. The same effect can be achieved by using a single polaroid and reflecting the light from a shiny surface.

### PhotoStress, Bonded to Part

The use of a reflective surface for photoelastic analysis has led to a very important discovery—that of bonding the photoelastic material directly to the surface to be analyzed.

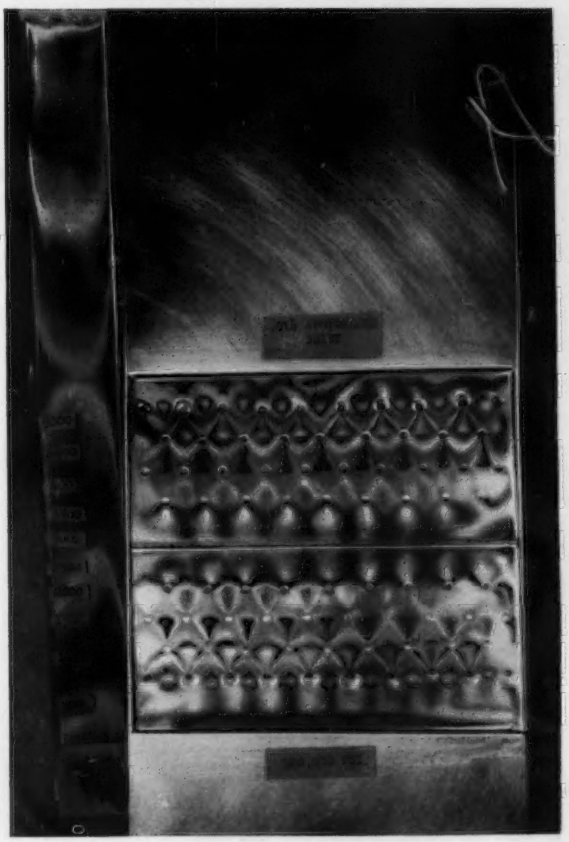
One such process illustrated here is called PhotoStress. Patterns resulting from this process may indicate stress distribution between rivets, like those of vinyl plastic model in Fig. 2. However, the patterns one sees are those for the test specimen itself, and not the plastic. This is because the modulus of elasticity for the specimen is many times higher than the plastic used. PhotoStress has the particular advantage of having a low modulus and a very high fringe constant, e.g., instead of 0.050 in./in. strain per fringe as in the vinyl plastic, a fringe would occur for only about 0.0005 in./in. strain in the PhotoStress. This is why PhotoStress lends itself for use in full size structures.

Fig. 3 shows a stress pattern for a spotwelded joint. Here, as in the riveted joint, an unequal distribution of stress between spots is observed. Also shown in Fig. 3 is a calibration bar consisting of an 0.064 thick piece of aluminum alloy covered with PhotoStress and bent over a riser so as to provide actual strain values from zero to 5000 microinches. Colors in the test specimen can be matched, with limited accuracy, against those in the calibration bar for quantitative measurements.

### "Accurate" Interpretation

More accurate results can be obtained by using a special meter having a light source at one

**Fig. 3. Spotwelded joint shows similar patterns. Calibration bar is used for better interpretation.**



polaroid and a separate polaroid for a viewer or analyzer. In this manner, the viewing polaroid can be rotated to determine fractional portions of fringes. In actual practice, the analyzer is rotated until the tint of passage moves to an original starting point. The amount of rotation required for this can be calibrated in terms of partial photoelastic fringes. Accuracies of $\pm 10$ microinches are claimed for this method. The Tatnall instrument is called the large field meter.

More accurate results can be obtained by using a microscope in conjunction with a Babinet Compensator. The Babinet Compensator is simply a calibrated tapered wedge of plastic such that a given number of units on the wedge will amount to one complete fringe order. The Tatnall instrument which performs this task is called the small field meter.

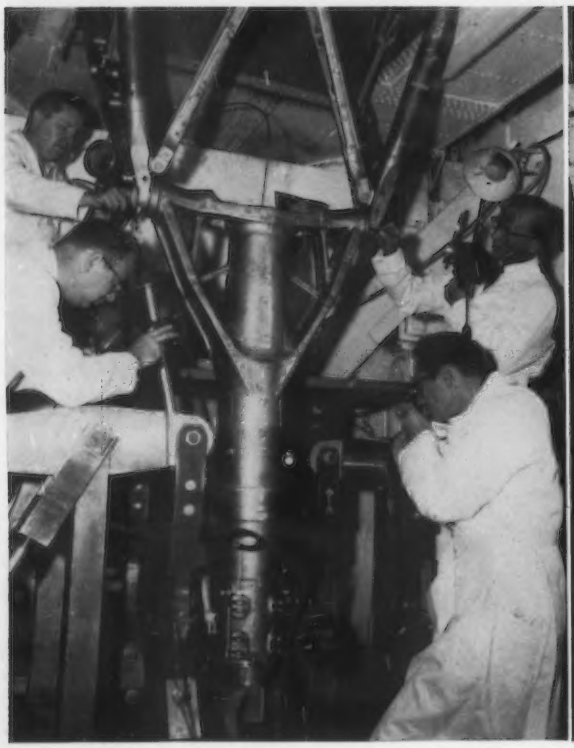
### Use Photoelastics as a Guide

Some will probably argue that PhotoStress is a pretty rough way of doing an experimental stress analysis. The main argument stems from the fact that the strains measured are differences in principal strains, rather than a strain in the direction of load, or in the direction of one of the principal strains. This is true of any type of photoelastic analysis. The general solution is to observe strains with respect to a free edge where the normal component could be assumed to be zero. Hence, the fringes represent the maximum principal strain.

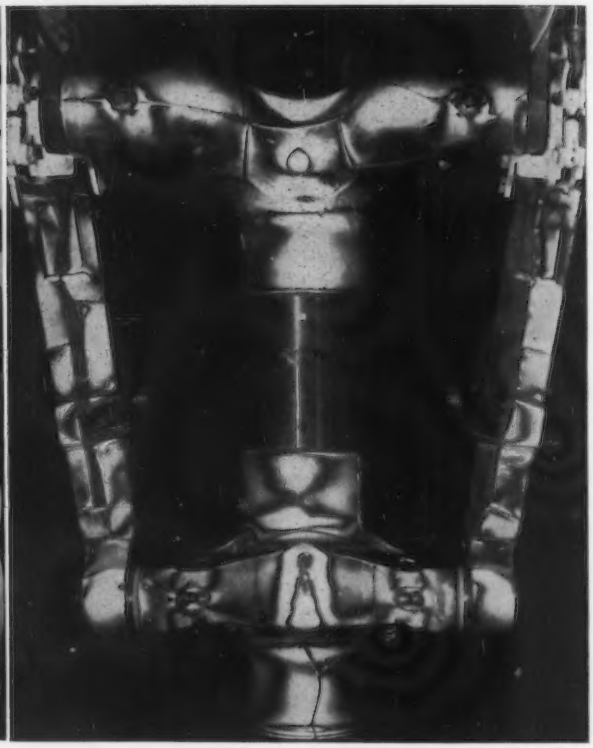
For determining values of both principal strains, the use of the oblique incidence meter is required. Describing the methods is beyond the scope of this article, but is definitely to be used by those who have more than a casual acquaintance with photoelastic principles.

**PHOTOSTRESS—PRACTICAL APPLICATION**

**Menasco engineers adjust field meters for "expert" evaluation of stress in B-58 landing gear. Loads will be applied hydraulically.**



**What they saw—is this neat stress pattern. Fringe areas will be marked with grease pencil for semi-permanent record, and later evaluation.**



In engineering problems, especially where fatigue is involved, approximations, even within 25 per cent, are much better than no information at all. A PhotoStress survey with even a hand polaroid will yield results that could tell the designer whether his structure was good or bad, or what would be required to fix it.

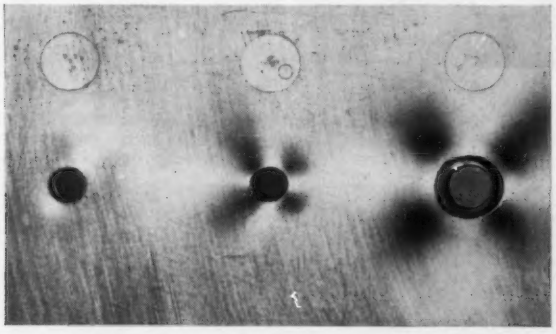
### Rivet Patterns and Fatigue Failures

All too often, fatigue failures are caused by having the structure too solid. PhotoStress analysis of a typical aluminum alloy butt splice having four rivets in tandem showed a maximum strain of 7000 microinches at the first rivet for a nominal strain value of 1330 microinches away from the joint. The strains at the remaining rivets amounted to 280, 1150, and 1350 microinches, respectively. A second specimen with the same rivet pattern, except that an extra rivet was driven through the edge of the doubler, showed strain readings of 2800, 1000, 800, and 1350 microinches for the four loaded rivets. The strain at the edge driven rivet was 3400 microinches. This amounted to cutting the strain in half by the mere addition of a rivet that could resist no axial load in the joint.

Subsequent fatigue tests on similar specimens for repeated cyclic stresses of from 0 to 10,000 psi nominal gross stress, showed the standard joint to have a life of 380,000 cycles, average for four specimens. The average life for those specimens with edge driven rivets was 1,700,000 cycles.

Another interesting experiment with PhotoStress is shown in Fig. 4, where the effect of drill sharpness and rivet expansion on residual stresses is shown. The test piece was 0.10 thick aluminum alloy. The hole at the left was drilled with a sharp drill and that in the center with a dull drill. Note that larger residual stresses remain in the hole drilled with a dull drill. The rivet shown at the right was driven after PhotoStress was applied using a small spotfaced area to permit forming the rivet head.

**Fig. 4. Effects of sharp and dull drills are shown in PhotoStress specimen. Hole at left was drilled with sharp tool; dull, leaves residual stresses.**



### Not How Much

Remember that it is not the stress so much as the distribution of stress that causes trouble. The use of photoelasticity in either, the direct, or reflected form, is a good indicator of stress distribution. Even with allowance for relatively large errors in measurement by the novice, the direction which a design should follow becomes very obvious. ✦

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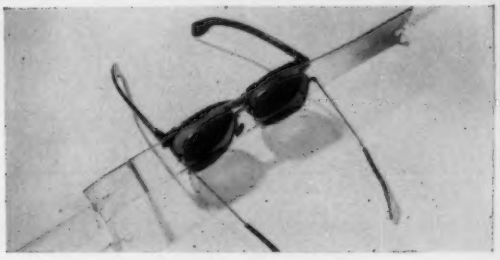
## • ABOUT PHOTOELASTICITY

One of the easiest experiments to make in photoelasticity is to stretch a piece of vinyl plastic (old garden hose or rain coat) between two pairs of polaroid sun glasses as shown. Light passes through the first pair of glasses and the color fringes can be observed through the second. The observer may even wear the second pair of glasses.

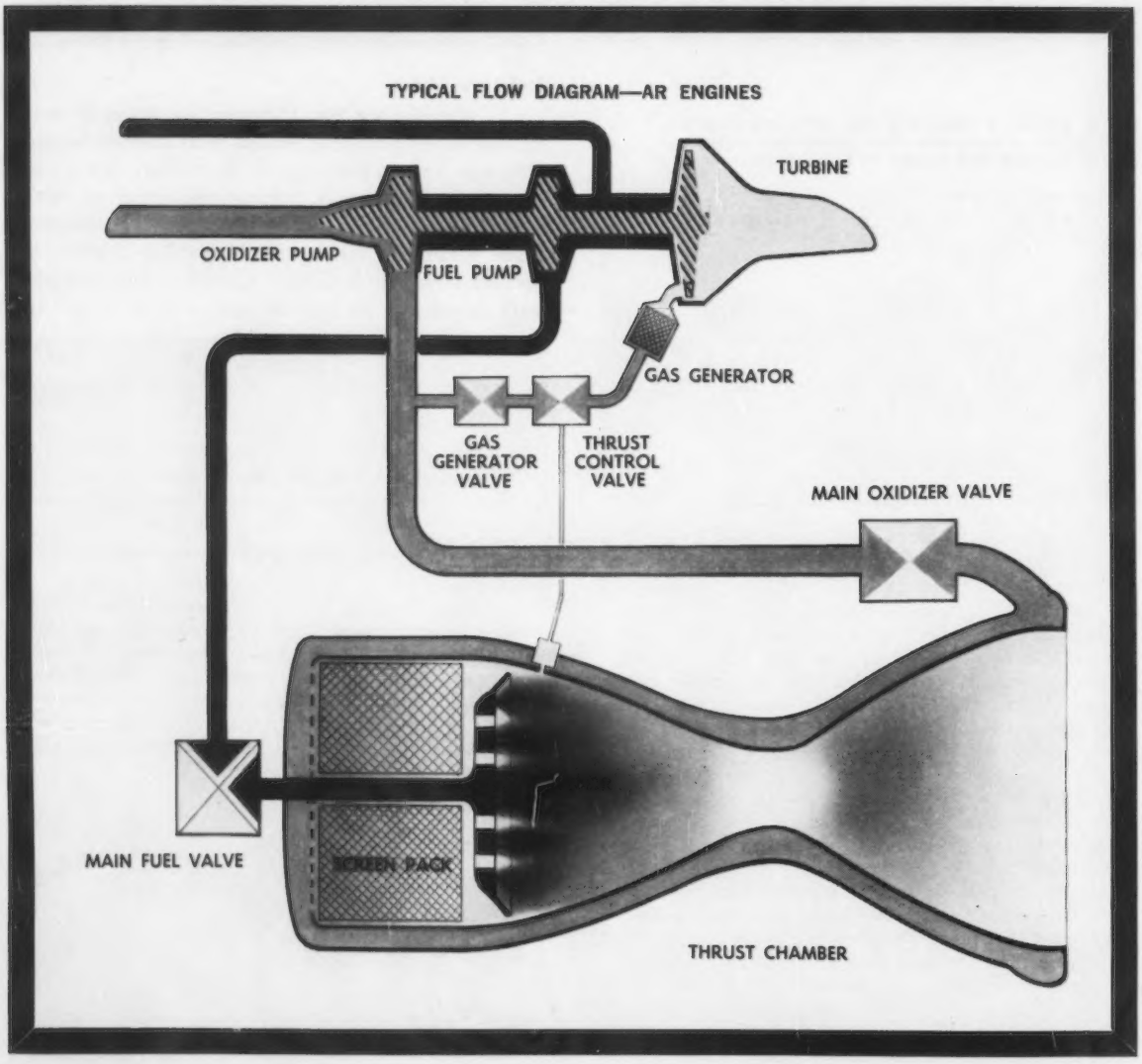
The reason for the fringes is that any birefringent material (material having photoelastic properties) when stressed will cause light to travel faster in the direction of tension and slower in compression.

Light, on passing through the first polaroid (sun glasses) is constrained to vibrate in a single plane. Provided that no stress exists in the plastic model, it will emerge and pass through the second polaroid unchanged. However, if the plastic is loaded, the beam of light is split into two beams (double refraction) whose wave motions are at right angles to each other. The beam whose vibration is in the direction of tension will emerge ahead of the other, so that when recombined by the second polaroid, interference between the two beams will set up color fringes. These can be interpreted in terms of difference in strains. If the polaroids are oriented so that their axis are in, or normal to the direction of tension, the difference will be of maximum principal strains.



# rockets for manned-flight

**throttlable, 6000-lb thrust units use $H_2O_2$/JP-4, designed for thrust augmentation in Navy fighters, may provide design seeds for larger rockets**



"Mighty oaks from little acorns grow." And, mighty rocket systems for manned flight may similarly grow from the throttlable, thrust-augmentation rockets being developed for Navy jet fighters. Experience has already shown, in the development of X-15 powerplant, that converting large missile engines for manned-flight is not a logical approach.

When Navy gave Rocketdyne Div. of North American Aviation a definite go-ahead on a liquid-fueled rocket engine for auxiliary propulsion on aircraft, less than 1 year was included in the time-table for actual engineering development.

Basic decisions had to be arrived at rapidly. Conventional pump and thrust chamber were selected. Hydrogen peroxide ($H_2O_2$) was chosen as the oxidizer and JP-4 as the fuel, on the basis of previous work. With hindsight, the choices have proven propitious.

### Design Objectives

Principal design objective was for manned safety. Related objectives:

- Simplicity — to facilitate maintenance and mass production.
- Interchangeability of components.
- Easy removal and replacement of entire engine.
- Safe-handling catalyst packs and propellents.

### Engine Configuration

The engines which evolved are known as the AR series, (AR-1, AR-2, AR-2-1, and AR-2-2). They have been used successfully on FJ-4 Fury.

Thrust-chamber unit consists of chamber itself, catalyst screen pack, and the injector. Thrust chamber is double-walled for regenerative cooling. It is fabricated of stainless steel.

Main catalyst pack, located in the dome of the thrust chamber, consists of silver-plated brass screens. $H_2O_2$ passing over the screens releases superheated steam and free oxygen. A smaller screen pack is used in the gas generator. This pack is similar in design to the larger.

The injector is the multi-orifice type. Tube-bundle, ring-slot, and multi-check valve designs were also considered.

Heart of the rocket engine is the turbopump. It includes the $H_2O_2$ pump, the fuel pump and the turbine drive. Combined weight is 36-lb. Fuel pump delivers 30 gpm against 1300 ft of head.

**Modifications of the AR-2 series are available as off-the-shelf items. Chamber geometry is apparent in assembly-line photograph.**

**AR2-2 is about 31.5 in. long, 15.4 in. diam. Flexible hose is used on $H_2O_2$ line. Propellant mixture is 7.3 to 1, JP-4 or JP-5 serve as fuel.**

### Problems—Solutions

SCREEN PACK opened two problem areas almost immediately. One, optimum thickness of silver plating to give rapid decomposition; two, degree of surface roughness on the silver plating to insure complete decomposition of $H_2O_2$.

Too heavy a silver plate causes excessive pressure drop across the screen pack, too thin a plating gives incomplete decomposition. The range is narrow. Exact thickness is proprietary. It is controlled in production, however, by shining a light through the screen and measuring the intensity of the light passing through. Controlling agitation of the plating solutions provides optimum surface roughness.

TURBOPUMP development posed the greatest hurdles. Problems were related mostly to seals and bearings. Complete sealing of $H_2O_2$ from JP-4 over extreme temperature, pressure and vibration ranges is necessary to prevent explosion. Material compatibility with the oxidizer complicates the issue. AR pumps have evolved as direct-drive devices, no gears being required.

**OPERATING CHARACTERISTICS OF AR-2 AT 35,000 FT**

| | |
|---|---|
| Oxidizer | 90% hydrogen peroxide |
| Fuel | JP-4 or JP-5 types |
| Thrust (full rated) | 6000 lb = 2722 kg |
| Specific Impulse (at full-rated thrust) | 238 sec |
| Oxidizer flowrate (at full-rated thrust) | 22.7 lb/sec = 10.3 kg/sec |
| Fuel flowrate (at full-rated thrust) | 3.12 lb/sec = 1.4 kg/sec |
| Thrust chamber flowrate (at full-rated thrust) | 25.82 lb/sec = 11.7 kg/sec |
| Nominal propellant mixture ratio | 7.3 |
| Thrust chamber pressure | 560 psia = 38 atm. |
| Nozzle expansion area ratio ($A_e/A_t$) | 12 |
| Nozzle throat area | 6.6 $in^2$ = 42.6 $cm^2$ |
| Dry weight of engine assembly, AR 2-1 | 225 lb = 102 kg |
| Dry weight of engine assembly, AR 2-2 | 240 lb = 109 kg |
| Oxidizer density at 60° F | 86.7 $lb/ft^3$ = 1389 $kg/m^3$ |
| Fuel density, JP-5 at 60° F | 50.5 $lb/ft^3$ = 809 $kg/m^3$ |
| Oxidizer pump NPSH required | 47 ft = 14.3 m |
| Fuel pump NPSH required | 44 ft = 13.4 m |
| Pneumatic purge supply required | 300 to 600 psig = 21 to 42 atm. |
| Electrical supply required, vdc | 28 (50 Watts) |
| Electrical supply required, vac | 115/400 cycles/ (3 Watts) |

Shaft is supported by prepacked ball bearings lubricated with extreme-temperature grease. Seals are mostly plastics of Teflon, Kel F, variety.

### Operation—Throttling

When the pilot activates a start-switch the $H_2O_2$ is forced into the gas generator by the aircraft boost pumps. $H_2O_2$ is decomposed into superheated steam and oxygen. These gases spin the turbine which drives the fuel and oxidizer pumps, and forces the propellants into the thrust chamber.

The $H_2O_2$ first flows through the double walls of the thrust chamber to provide regenerative cooling for the engine. It is then directed through the main catalyst screen pack where it is decomposed. The heat of decomposition ignites the fuel in an oxygen-rich atmosphere. By controlling the amount of $H_2O_2$ which goes into the gas generator, it is possible to regulate the speed of the turbine which drives the pumps. This is the basic concept used in throttling the engine.

The engine is throttlable between 2000 and 6000 lb of thrust. Additional hardware is available to boost thrust to 12,000 lb. Rocket throttle is integrated in the jet engine control lever. Controlling device is an electrical mechanism which references the operating pressure of the thrust chamber to the setting of the pilot control. The controller then applies the command to fuel flowing to the gas generator. The resultant gain or loss of pressure controls turbine speed and thereby varies output of the pumps.

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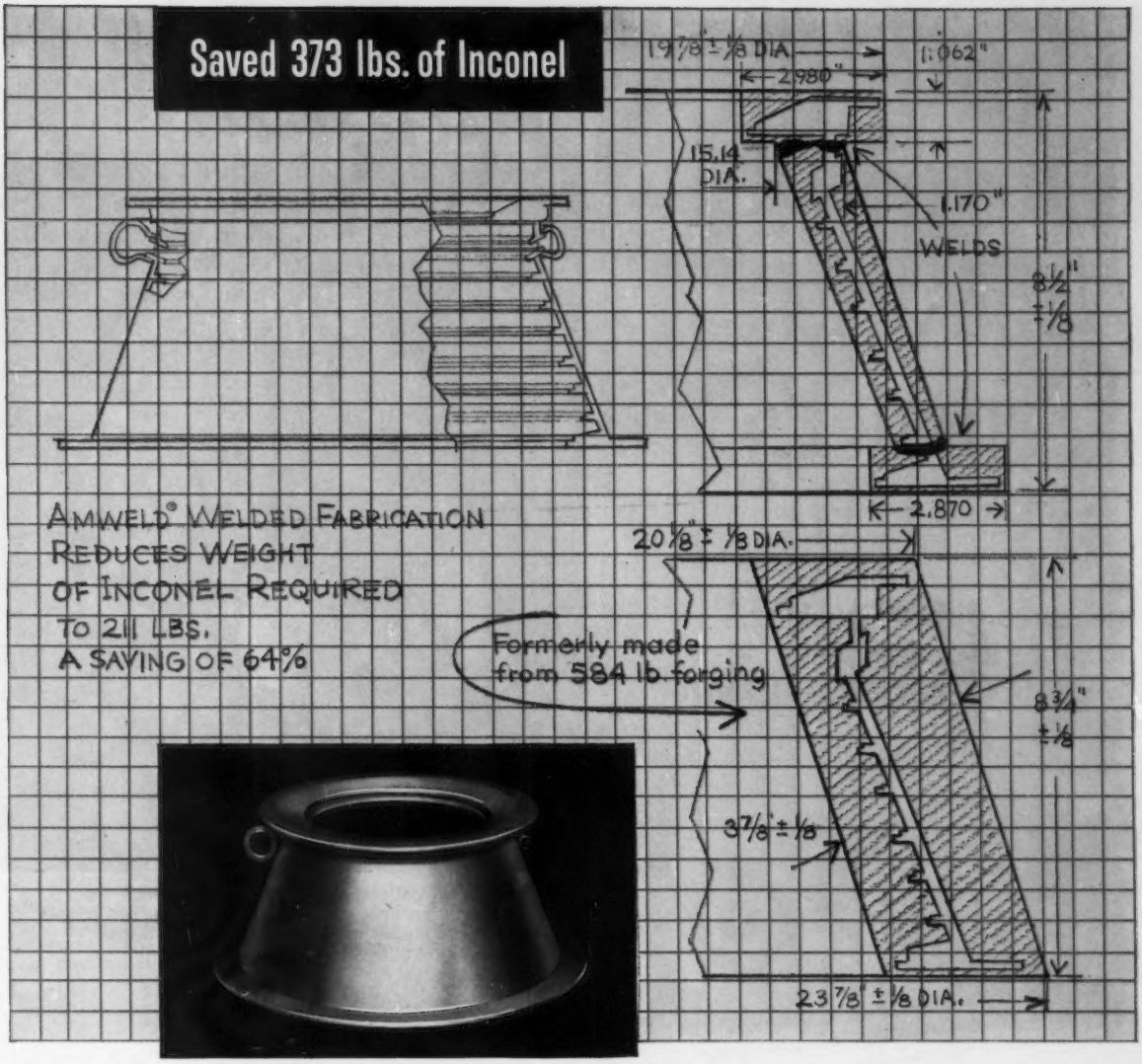
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19 7/8" ± 1/8 DIA.
2.980"
1.062"
15.14 DIA.
1.170"
WELDS
8 1/2" ± 1/8
2.870
20 1/8" ± 1/8 DIA.
AMWELD® WELDED FABRICATION REDUCES WEIGHT OF INCONEL REQUIRED TO 211 LBS. A SAVING OF 64%
Formerly made from 584 lb forging
8 3/4" ± 1/8
3 7/8" ± 1/8
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# AMERICAN WELDING

# electronic micrometer

**measures without touching, accurate to one per cent over 0 to 45,000 micro-in. range**

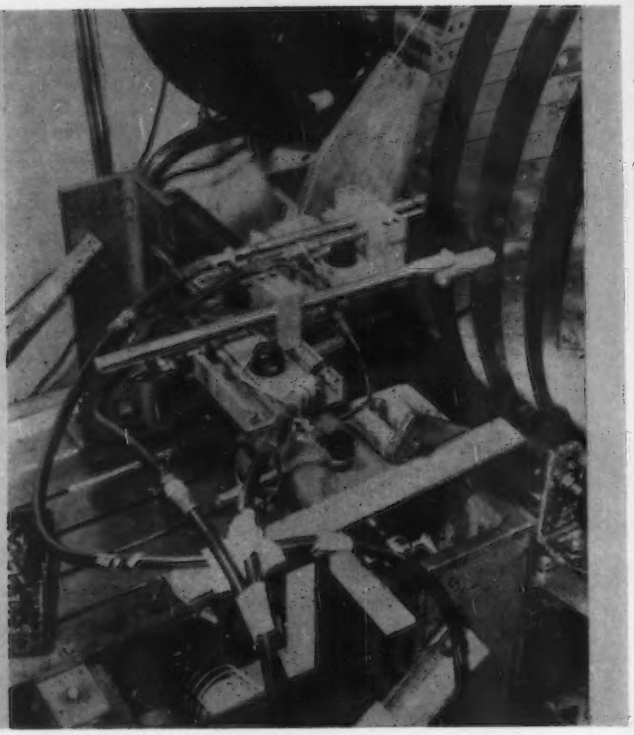


**Fig. 1. A typical test setup is shown in which the specimen is an axial-compressor rotor. The two probes measure the elastic radial dilation and the degree of tilt of dummy blades.**

Development work in gas-turbine engineering often involves measurement of the distortion occurring in compressor and turbine-rotor assemblies at high rotational speeds. The observations required may be the straightforward diametral growth of simple disks or more complicated axial deflections caused by system asymmetry, states a report from England's Bristol Siddeley Engines, Ltd.

Measurements of this type are made using a non-contacting device, such as the Wayne Kerr Electronic Micrometer, Type B-721, the accuracy of which is unaffected by the peripheral speed of the specimen. Although optical devices have been used, the capacitance-probe system illustrated here has proved to be the best solution to this problem from the point of view of both the accuracy of measurement and the range of observations. This new Micrometer, made by Wayne Kerr Co., Ltd., in England, is marketed in the United States by the firm's subsidiary, Wayne Kerr Corp., Philadelphia.

This portable instrument measures with high accuracy and discrimination, distances from 0 to 45,000 micro-inches. The limitation on measurements near zero is determined only by the surface finish of the instrument probe and that of the object under investigation. Range is determined by the size of the probe used and the instrument is normally supplied with two probes to cover the range up to 0.045 in. Wayne Kerr provided special large probes for a Bristol application to permit measurements up to 0.080 in.

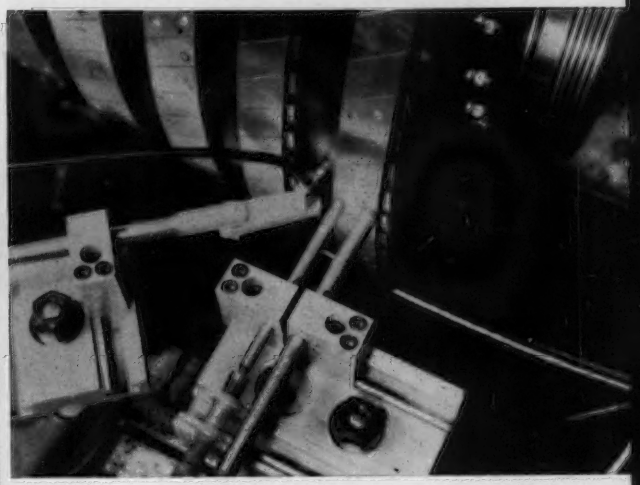


Fig. 2. Swivel-head probe (first from left) measures radial dilation of interstage space ring.

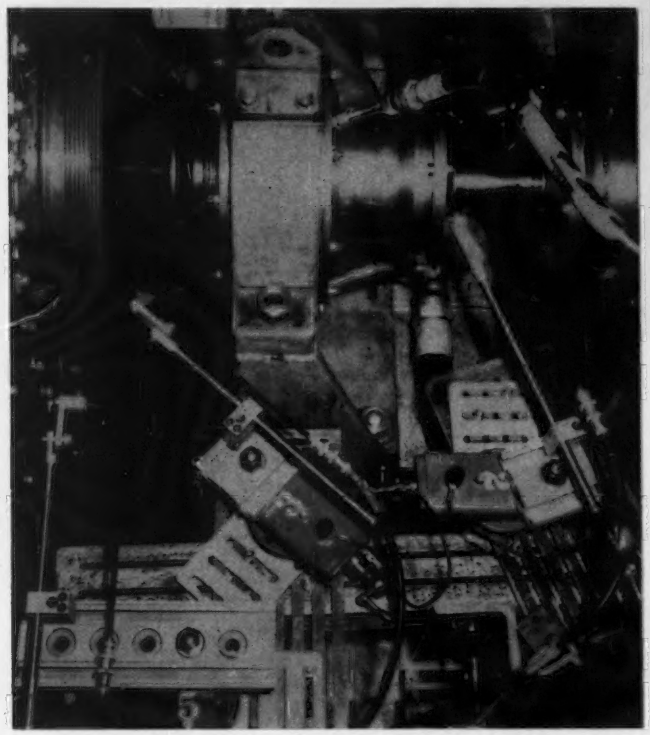
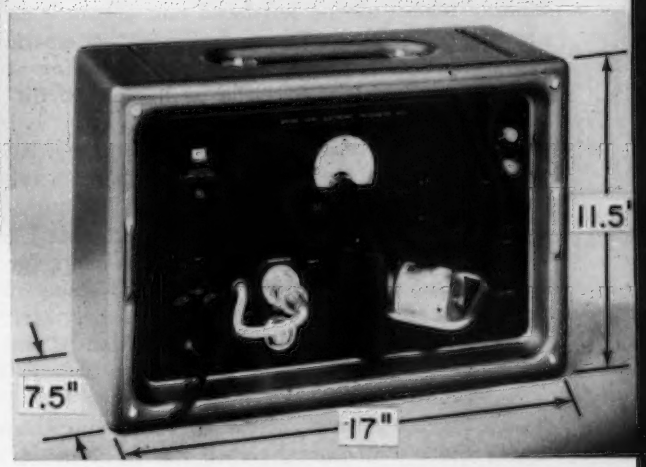


Fig. 3. Three swivel-head probes are used here, Left-hand probe measures labyrinth seal radial dilation, center probe reads deflection of coned end surface, and right-hand probe measures datum indication of rotor axial position in its bearings.

Compact dimensions of Wayne Kerr Electronic Micrometer Type B-721 are shown.



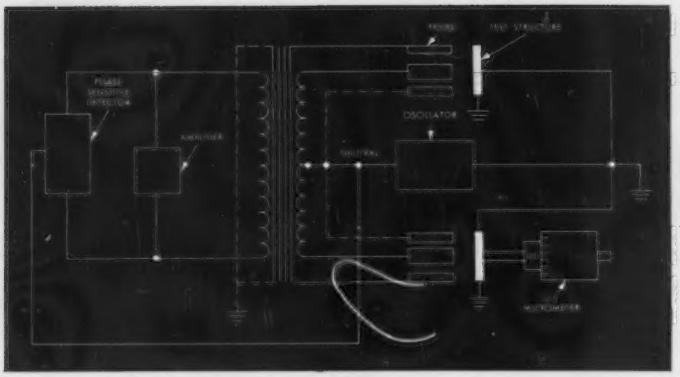

The design of the instrument is based on the transformer ratio-arm bridge principle. The standard for the bridge circuit is a three-terminal parallel plate capacitor adjusted by a micrometer. The unknown is also a three-terminal parallel plate capacitor formed by the probe and the test object. The ratio of the two capacitors is 100:1 or 10:1 according to which of the two standard probes is used. These ratios allow small distances between the probe and the test object to be measured and effectively increase the discrimination of the micrometer. The user need not concern himself with the electronics since any change in distance between the test object and the probe is given directly by the change in the micrometer setting required to balance the meter to zero.

The capacitance of the probe cables does not form a part of the measurement circuit, so that the probes can be operated at distances of up to 75 ft from the instrument; source and detector are incorporated in the instrument and balance is indicated on a center-zero meter.

Because no physical contact is necessary, accurate determinations of temperature coefficients, moduli of elasticity, rigidity, and bulk, Poisson's ratio and dilation can be made even on fragile samples. The equipment is particularly suited to measurements on rotating objects and for monitoring distance with reference to a predetermined value.

Fig. 1 shows a typical test setup in which the specimen is an axial-compressor rotor. For

# electronic micrometer . . . continued



A typical test setup circuit is seen incorporating the Transformer Ratio-Arm Bridge principle utilized by the Wayne Kerr Electronic Micrometer.

test purposes the blades have been replaced by dummy-blade weights of equivalent mass to the true blading; the periphery of the weights has been ground to provide a cylindrical reference surface. The two guard-ring probes in use on the dummy blades at the left-hand end of the compressor rotor are used to indicate the elastic radial dilation and the degree of tilt occurring at this point. The fact that the probes are of different diameters is of no consequence.

The remaining probe which is fitted with a swivel head, is sensitive to displacement in the axial direction, and is measuring the axial movement at the side of the dummy-blade weights.

Fig. 2 shows a similar arrangement for dilation and tilt measurements at one stage of dummy-blade weights, but in this case a third probe is in use to measure radial dilation of the interstage space ring.

Fig. 3 depicts the use of three swivel-head probes. The left-end probe is measuring the radial dilation on the labyrinth seal. The center probe is to indicate the deflection of the coned end-surface, and the third probe gives a datum indication of the axial position of the rotor in its bearings.

Although the Wayne Kerr system does not require any external means of calibration when used with ideal pickup probes of known effective area, Bristol prefers to carry out individual "as installed" calibrations of every probe. This accommodates any errors due to lack of parallelism of the probe face and the specimen surface, and removes any restrictions imposed by the manufacture of very accurately machined probes. The calibration system used is both simple and effective. Probes may be mounted singly or collectively on a modified lathe saddle, and may be traversed by the graduated lead-screw to give the calibration required.

The type of measurement made with a probe having an overall diameter of $\frac{3}{8}$ in. is as follows:

(a) Initial gap: 0.080 in.
(b) Gap in full-dilated condition: 0.020 in.
(c) Dynamic range: 0.060 in.
(d) Discrimination: better than 0.0002 in. at 0.080 in.
(e) The general accuracy of measurement for the bare equipment is considerably better than $\pm 1$ per cent, but the overall accuracy under test conditions is influenced by other factors, such as rotor movement in the bearings, and general mechanical and thermal distortion of the setup and probe supports as a whole. It is estimated that under favorable conditions measurement accuracies are of the order of $\pm 2$ per cent.

Tests to determine the possible influence of either the material of the specimen or its peripheral speed have been carried out on both light alloy and ferrous disks at peripheral speeds of up to 1000 ft/sec. The results have indicated that these factors do not influence the validity of the measurements.

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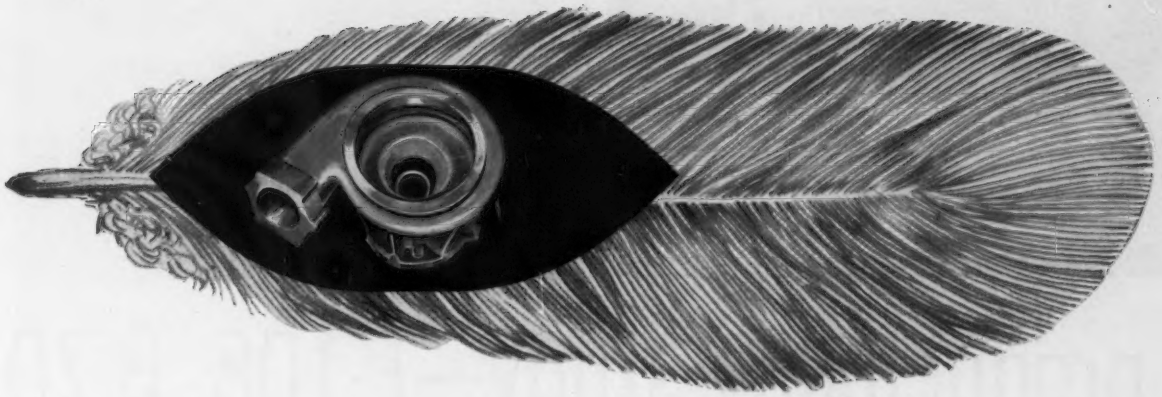


## NEW HIGH-STRENGTH . . .
## HIGH-PURITY ALUMINUM CASTING ALLOY

If you've been pushing A-356 to the limit of its physicals to scrape off every possible ounce of excess weight . . . then new alloy MA-356 was made to order for you. With a few minor changes in chemical composition, Rolle has produced what is essentially a new casting material. Highly responsive to heat treatment, it permits higher tensile strength, higher yield strength, and greater elongation. Rolle is pouring MA-356 now . . . in castings that consistently exceed the physical requirements of MIL-C-21180A. Check, for example, the typical sand cast range of properties MA-356 permits in the T-6 condition against what you can expect from conventional A-356 at left:

| ALLOY (T-6) | U.T.S. (psi) | Y.S. (psi) | E (%) |
|---|---|---|---|
| A-356 | 40,000 | 30,000 | 3 |
| MA-356 | | | |
| minimum | 40,000 | 30,000 | 5 |
| maximum | 50,000 | 40,000 | 2 |

One of the advantages of MA-356 is that any desired physical within the typical range can be emphasized through careful control of heat treatment of the casting. Even more exciting are the extremely high physicals that have been achieved with MA-356 in favorable casting configurations. Test castings have actually exceeded a tensile strength of 54,000 psi and yield strength of 44,000 psi with 2% elongation.

*But no two castings are alike.* It's impossible to predict the benefits MA-356 will confer on your sand and permanent mold castings without prints and specs. If you'd like more information on this new alloy, write for Technical Data Bulletin 1001. And when you do, why not ask for your copy of our 58-page light metals casting handbook . . . an engineering guide to aluminum and magnesium sand and permanent mold castings. Rolle Manufacturing Company, 317 Cannon Avenue, Lansdale, Pennsylvania, or call ULysses 5-1174.

ROLLE

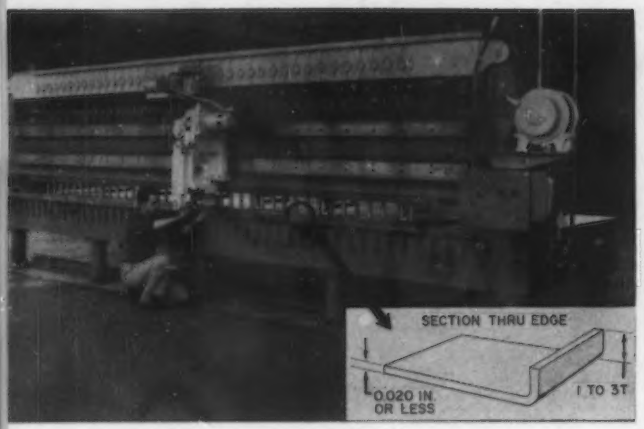



Fig. 1. Edges of large stainless sheets are roll-sheared straight and true. If sheet is 0.020 in. or thinner, fold-over flange is created for fusion welding.

# producibility study—F-108, B-70

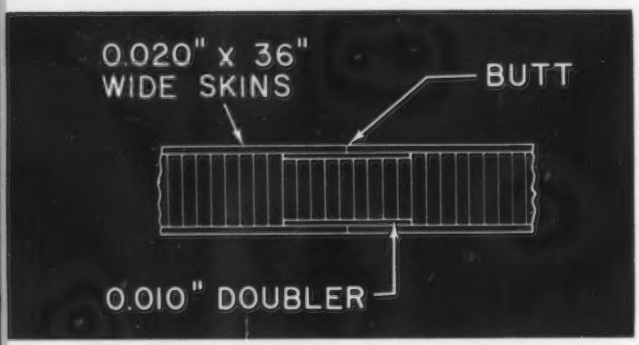



Fig. 2. When large sheets are joined by brazing, doubler is brazed in milled core slot. Brazing alloy is placed between all interfaces. Sheet-to-doubler, doubler-to-core and sheet-to-core joining is effected in one operation.

## how NAA will build Mach 3 aircraft is result of industry-wide study; 'best' materials and methods revealed

by Philip Geddes

Structural design objectives for North American Aviation's F-108 and B-70 have several common requirements:

- light-weight, high strength structure.
- low drag—aerodynamic smoothness.
- low heat transfer from hot 450°-600° F skins.
- reliability—strength at high temperatures, fatigue resistance, rigidity, producibility at reasonable cost.

Brazed honeycomb sandwich structures with PH 15-7 Mo Cres skins satisfy many of these objectives. The F-108 is designed with approx 3500 sq ft of brazed honeycomb sandwich and the B-70 with approx 20,000 sq ft. Applications include large fuselage areas, engine intake ducts and control surfaces—many sandwich areas have complex curved surfaces.

### Manufacturing Development Program

Close cooperation between design and production groups was assured from the start of the program by organizing Manufacturing Development Programs (MDPs). The basic objective of each MDP was to create practical hardware and smooth the transition of such hardware from lab to shop.

Fourteen MDPs exist today. The working structure of each MDP has been well defined. A project manager, carrying full responsibility, heads each group. Representatives from engineering, tooling, production, and quality control take a place on each team. When a particular project comes to an end, the group is dissolved and the members return to their original departments where they carry out the work they developed in the MDP. The shop department

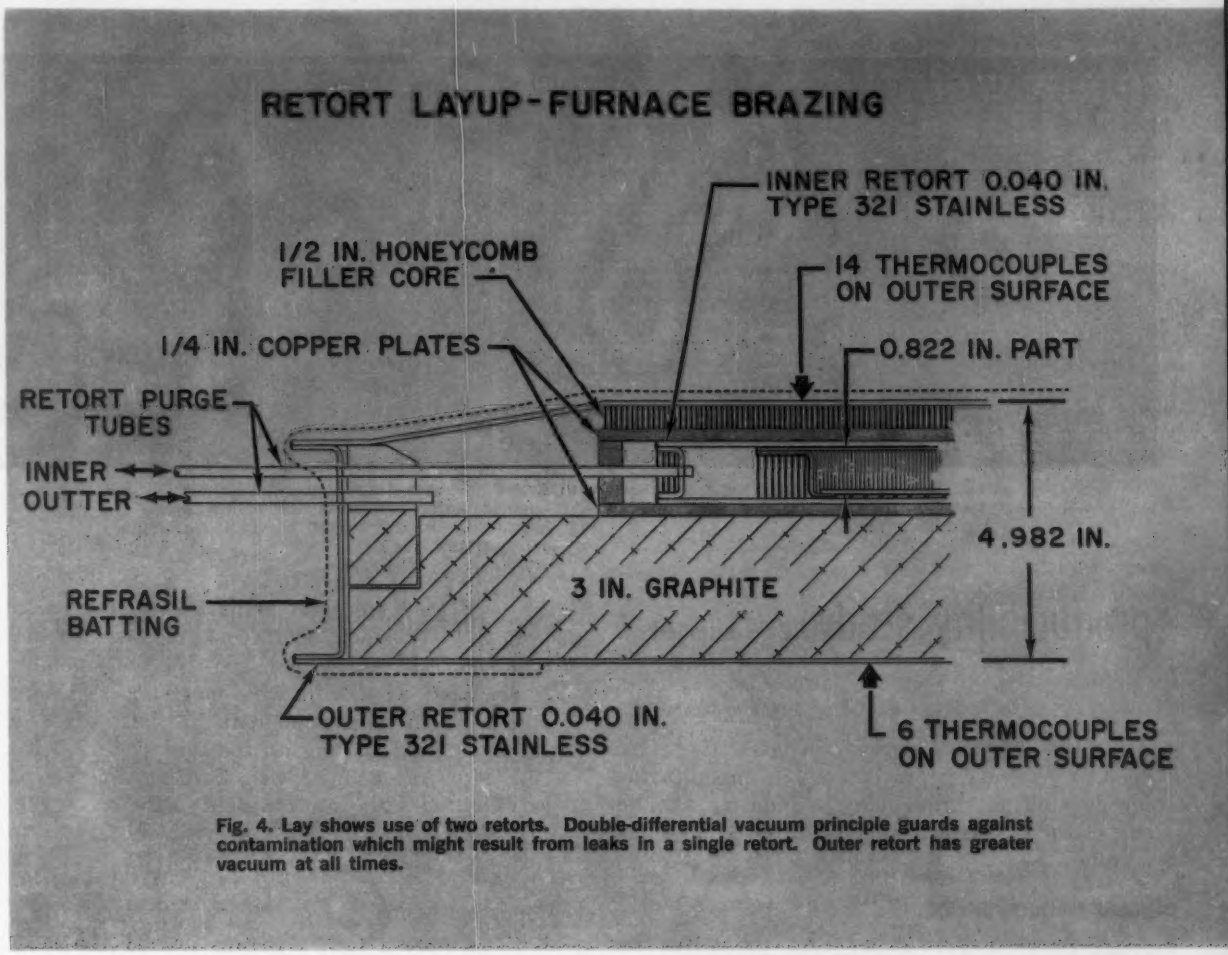
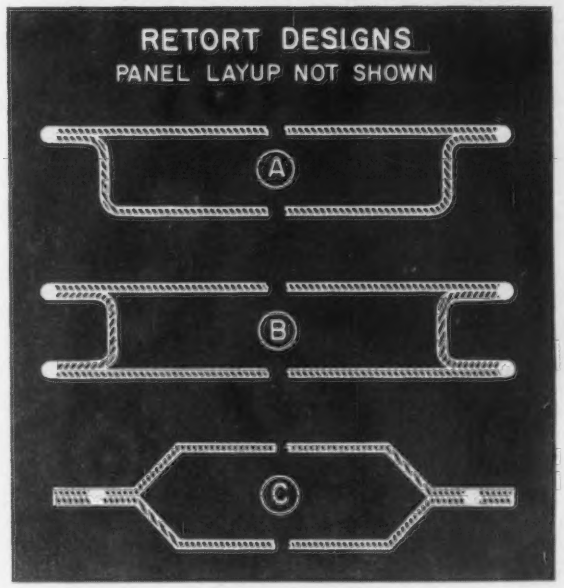



**Fig. 4. Lay shows use of two retorts. Double-differential vacuum principle guards against contamination which might result from leaks in a single retort. Outer retort has greater vacuum at all times.**

**Fig. 3. Three types of retorts are used: (A) hand fusion weld, (B) resistance seam weld, (C) automatic heliarc fusion. Material is 321 stainless or hotroll carbon steel. Inner retorts are 0.020, outer retorts 0.040 in. thick.**




representative generally becomes production supervisor for that phase. Interchange of information between teams is assured by key people being involved in several projects at once.

### Producibility

Realistic work loads were established by the engineering department designing a set of brazed honeycomb assemblies to test producibility. A wing box, dive brake door, duct, and elevon were considered representative of the complexity anticipated in the overall project. If a facility could be established to build these parts, the production of the actual aircraft would be judged realistic using the same methods.

A backup program in which North American subcontracted similar producibility assemblies to a series of select companies was run con-

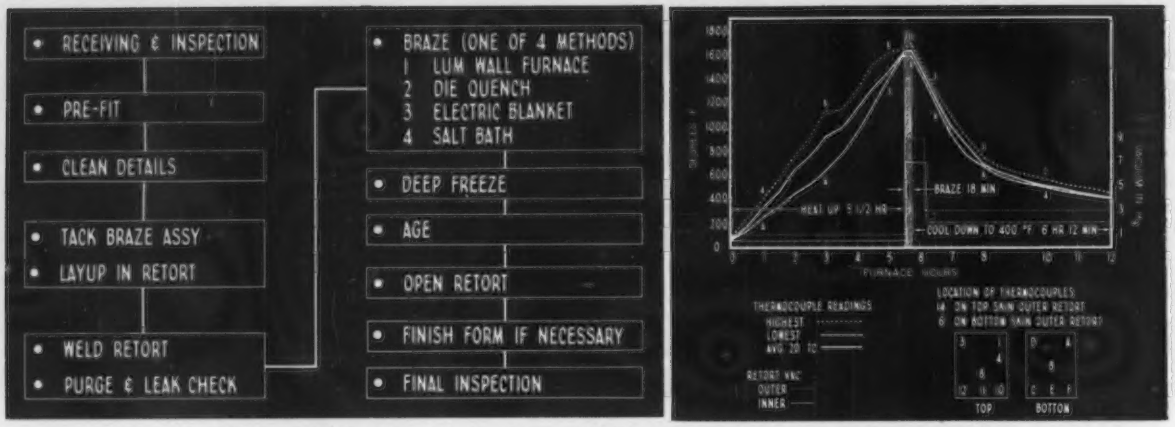



**Fig. 5. Complete brazing cycle is shown with time-temperature curve of typical panel. Twenty thermocouples are used on 10x14 ft panel. Retort vacuums are shown on right-hand scale.**

## producibility study... continued

currently. North American believes there has been a general improvement in manufacturing capabilities throughout the industry as a result of the free interchange of information which resulted.

### Sheet Metal Fabrication

Large PH 15-7 Mo Cres Skins for the producibility assemblies were made by three methods:

- welding together mill-size skins.
- pack rolling.
- braze lap joining mill skins.

Where welding was used, skins were first prepared by stretch-flattening mill-size sheets. Edge preparation prior to welding consisted of precision trimming skins and bending a flange on skins less than 0.020 in. after trimming. The flanged 0.020 sheets were butt fusion machine welded together without adding filler wire. Heavier sheets were butt welded adding filler wire. A 10 ft automatic heliarc welder with argon backup cup and copper chill bars was used to weld skins. This welder is capable of making up any skin length. Welding skins introduces stresses adjacent to joints. These stresses, visible as waves on the sheets, are removed by stretch flattening.

Pack rolled facing skins of 0.020 in. thickness up to 11 x 25 ft in size have been produced by U. S. Steel, Pittsburg. (See "Rolling Wide Stainless Sheets," AMM, May 1958.)

Brazed lap joint skins are used to make a 10 x 14 ft panel. The skins are flattened and trimmed. The honeycomb core for the assembly is prepared with 2 in.-wide 0.010 in.-deep slots milled out to correspond with the butt edges of the five sheets making up the face skins. A PH 15-7 Mo Cres doubler with brazing foil placed between faces fits into the slots in the core (Fig. 2). Skins braze together, as well as doubler to core and skins, making up strong joints.

### Honeycomb Core

Abrasive belt grinding proved the most successful method of machining the PH 15-7 Mo honeycomb sandwich core. Constant height parallel wall core is used in most places.

Several different machines proved effective in belt grinding. The biggest used was a 7 x 40 ft Farnham with gantry head, on which large core panels could be ground to $\pm 0.001$ in. tolerances. Core was held to the machine by means of an ice chuck. Smaller core panels were handled by Engelburg and Curtis machines, both of which were capable of holding $\pm 0.001$ in. tolerances, with burrs falling within the maximum 0.005 in. allowed. Entry and exit edge crushing was prevented by impressing sheets of $\frac{1}{8}$ in. beeswax into the first and last one inch of core. A Curtis stroke sander, essentially a woodworking machine, is being developed for grinding shaped core. A cam contour follower in the completed machine will automatically control machine operation. Contoured core is finished in a 16-ft Rockford planer. This planer is equipped with True-Trace 180 deg profile control equipment guiding a 4 in. wide abrasive-belt grinding head. In some cases core required reburring.

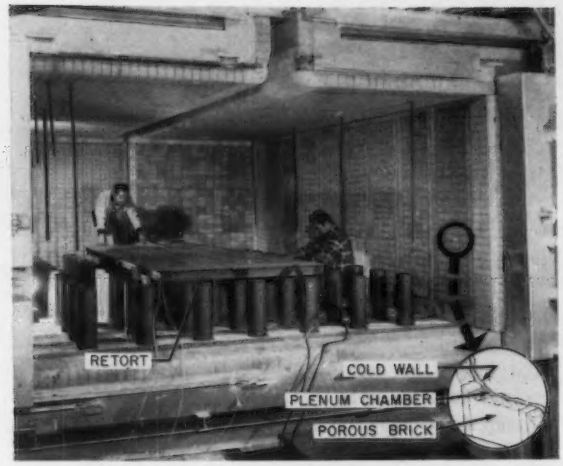



**Fig. 6. Retort is being instaled in luminous-wall furnace. This type of facility has several advantages, all associated with rapid heat response. Brick walls are heated to incandescence.**

Both vapor honing and hand finishing with suede shoe brush were effective. Disc cutting was investigated but proved less successful than abrasive grinding in machining large surfaces. Disc cutting has its place in making small cutouts.

ICE CHUCKING was used extensively to hold core down for machining. The chuck is painted with water to which a gelling agent has been added to prevent undue run-off. Ethylene-glycol refrigerant pumped into the chuck from a refrigerating unit solidifies the gelled water in two to three minutes. During this time the work is held down by vacuum pressure.

ELECTRIC MACHINING has found a place in future core shaping operations. A 2000 amp Anocut unit mounted on a 3 x 14 ft Bridgeport surface grinder fitted with contour tracing equipment was used to shape the core for the vertical stabilizer tip. An Elox machine proved useful for making odd geometry holes.

## Pre-Brazing Operations

The critical operation in manufacturing honeycomb sandwich lies in the brazing operation. Several factors must be rigidly controlled:

- prevent oxidation.
- insure temperature uniformity during heat-up.
- make brazing temperature compatible with heat treat cycle of PH steels.
- provide pressure to hold details in intimate contact.
- cool rapidly and uniformly.
- maintain shape of part during cooling and subsequent heat treatment.
- use only dimensionally accurate, clean, and stress free, details.

The sequence from prebrazing preparation to final inspection of completed assembly is illustrated.

PREFIT. In-process inspection during the prefit operation is carried out in specially designed jigs. Air gaps between brazing interfaces are held to a maximum of 0.004 in. as brazing metal will not bridge larger gaps. A complete set of parts comprising an assembly is carefully matched in the prefit jig. The set is then disassembled into an individual storage box.

CLEANING. Core and details are wired separately to expanded metal frames and cleaned in a conventional nitric acid and hot alkaline cleaning sequence. Brazing foil is cleaned in separate tanks not used for any other purpose.

TACK BRAZING. After prefit and cleaning, work must be laid up in an inert atmosphere within 96 hr, or recleaned. Three operations which follow: tack brazing, spot welding core, and layup of assemblies in retorts, are preformed in a dust free room. Sterling silver lithium alloy foil 0.002 in. thick is tack brazed to the brazing interfaces wherever a brazed joint is wanted. The foil must not be allowed to move in relation to the prefitted parts. A 10 KW Seedorf power unit with a single probe gun is used for tack brazing in difficult places but a "C" type dual electrode gun is preferred in most applications. Inserts and closeouts must be tack brazed to the adjacent core. Tack welding is employed to join edges of pieces of core making up large panel assemblies. As an example, in a 10 x 14 ft panel there were four 5 x 7 ft cores to be joined.

RETORT LAYUP. Since oxidation must be prevented, each assembly must be brazed in an inert atmosphere. Parts must be held in intimate contact during the brazing cycle to make effective brazed joints. These two factors make it necessary to enclose the assemblies to be brazed in thin hermetically sealed envelopes, retorts, in which a partial vacuum is drawn. Outside air pressure forces the thin walls of the retort down onto the inner assembly producing even pressure to hold the separate parts together. When large assemblies are to be brazed a retort is laid within a retort. Where graphite tooling is required for contour control during the brazing cycle, North American uses a double retort with the graphite positioned in the outer retort. In this way the graphite cannot contaminate the sealed inner retort. The final operation in the dust free room consists of laying the honeycomb sandwich assembly in a retort then tack welding the retort shut. Final welding is performed outside the dust free atmosphere to minimize air pollution. Retort design is discussed in the following paragraph.

*continued on next page*

RETORT DESIGN. North American uses three retort designs. They are illustrated. The first is preferred, but size restrictions on the lower pan limit use. The second, using a "U" section close-out, can be made any size desired. The first two are generally used in furnace brazing, the third in die quench or electric blanket brazing. Retorts were originally made from 321 stainless steel but experience showed hot rolled carbon steel or 1020 retorts are cheaper and easier to weld. Provision for a vacuum connection is made on each retort.

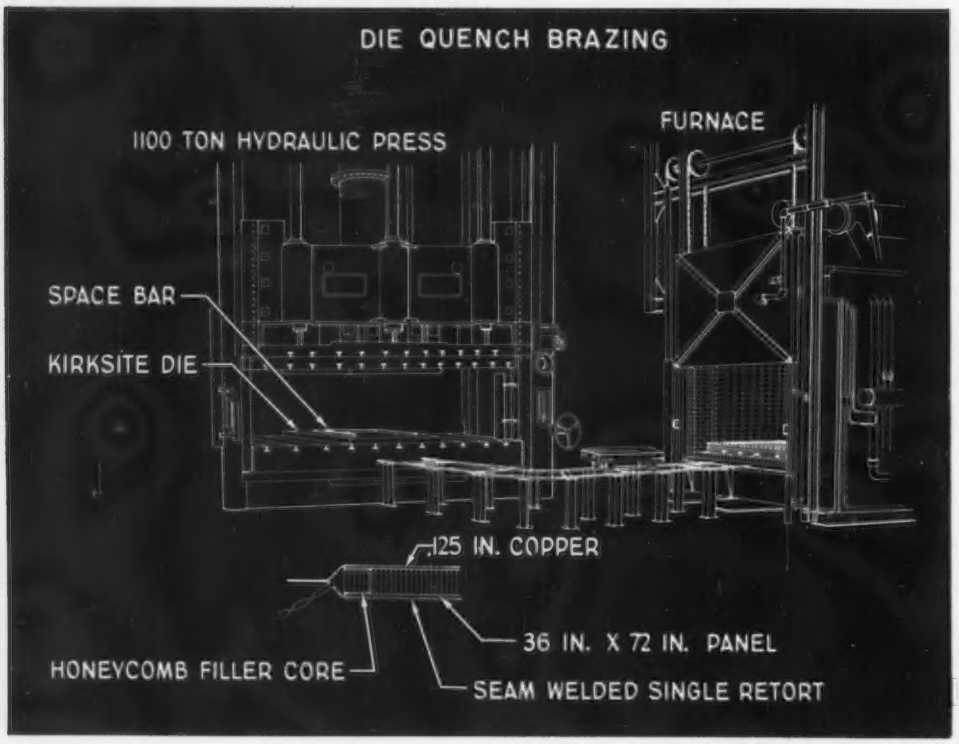
GRAPHITE TOOLS, used only in outer retorts, provide contour control during furnace brazing. Graphite tooling has several desirable properties:

(1) tooling becomes stronger with temperature increases well beyond brazing point.
(2) cuts like wood; easy to work using standard wood working tools.
(3) since used in outer retort only, does not require hi-temp storage or pre-use baking to eliminate moisture.
(4) easier to finish than kirksite dies.

PURGING. Before brazing, oxidizing air must be replaced with inert argon.

Inner retorts are purged a minimum of seven times and outer retorts three times. In cases where a small single retort is used, as in electric blanket and die quench brazing, the purging cycle is run through and then the vacuum inlet pigtail welded shut. This leaves a low pressure argon atmosphere around the honeycomb assembly. A double differential vacuum principle is used in furnace brazing operations where the inner retort is held at a lower vacuum than the outer. Vacuum pressure is adjusted by the operator during the temperature changes in the brazing cycle. Different thickness honeycomb panels require different pressures to hold the assembly together on the graphite reference base in outer retort. The outer retort forms a sheath over the inner retort allowing slight leaks in the inner without air contamination. The lower-than-atmospheric pressure drawn in single and double retort operation, ensures that the force of the outside air pressing down on the thin retort skin keeps the parts comprising the honeycomb sand-

Fig. 7. In die-quench brazing retort is heated in furnace at right. Cart then moves retort to press (left) where it is charged into water-cooled Kirksite die.



wich assembly in close contact. However, a certain amount of clearance must be given to allow for differences in expansion rates between metals in the assembly during brazing.

### Brazing Equipment

North American used four different brazing methods to produce the F-108 and B-70 producibility assemblies:

- luminous wall furnace for large parts.
- electric blanket for complex curved parts.
- die quench for flat and modestly curved parts.
- salt bath for heavy section parts.

LUMINOUS WALL FURNACE offers the advantages of rapid heat up, forced cooling, and rapid temperature response with accurate zone control. The very high heat input and rapid cooling when desired, coupled to an effective temperature control, work well for the critical brazing operation where time/temperature must be closely controlled. Fig. 4 shows the retort layup used in furnace brazing the 10 x 14 ft panel. Refrasil batting around the outside of the outer retort protect edges from cracks and leaks. A total of 20 thermocouples with the thermocouple heads removed, were spot welded on the bare wires to the outside skins of the outer retort.

In the example of furnace brazing layup illustrated in Fig. 4, heat input to the inner retort is balanced by the use of a 3 in. graphite block below the inner retort and ½ in. honeycomb filler core above. It is believed that the costly upper filler core can be eliminated by placing the inner retort between two slabs of graphite of equal thickness. Temperature gradients across the retorts produced surface wrinkles on large flat panels before the use of the ¼ in. copper plate. Deoxidized or phosphorized copper must be used or oxygen in the copper may produce steam pockets which cause bubbles on the skin of the honeycomb panel.

Time temperature and vacuum readings from the brazing cycle for the 10 x 14 ft panel in a luminous wall furnace are shown in figure 10. This cycle was successful despite the apparent erratic rise to brazing temperature and high temperature differential between retorts. The high differential would have destroyed work heated to brazing temperature without copper plates around the inner retort. Furnace time was cut to a minimum (12 hours) as a cost reduction measure.

ELECTRIC BLANKET BRAZING. Two types of electric blanket brazing are being investigated. The first, using deadweight tooling and a single retort was derived from work methods originating at The Martin Co., Baltimore (see Electric Blanket Brazing, AMM, April 1959). The second, using a ceramic reference base, is still being evaluated. Lockheed-Marietta, Georgia, is using a Glassrock reference base in their similar tooling. Kirksite reference bases with cooling jackets are also being tried.

DIE QUENCH BRAZING uses a single retort. The retort, containing the honeycomb sandwich assembly to be brazed, is installed on a cart and moved into a furnace. The furnace having previously been fired and brought up to brazing temperature (1625°F) while empty. The retort temperature is rapidly raised to brazing point. The retort, still on the cart, is shifted out of the furnace and moved rapidly to an adjoining press. The retort is removed from the cart and placed onto a kirksite die. The press is lowered to the surface of the retort; kiss bars prevent the top die from squashing the envelope. The heat of the retort is rapidly absorbed by the dies—hence, die quenching. (See Fig. 7.)

SALT BATH BRAZING offers the advantages of rapid heat up with accurate temperature control. This method is still being evaluated.

### Post Brazing Operations

SUB-ZERO TREATMENT. All brazed honeycomb sandwich assemblies are passed through sub-zero treatment after brazing. Here the assemblies, still in retorts, are subjected to —110°F temperature for min. of 3 hours.

HEAT AGE. Heat aging or precipitation hardening is performed after sub-zero treatment in conventional furnaces with the work under vacuum in retort. The time of heat aging varies with the braze cool down time. If the braze cool down time from brazing temperature to 1000°F is within 45 min but greater than 5 min aging time becomes 8 hr at 900°F. After heat aging the retorts are opened and the brazed sandwich removed.

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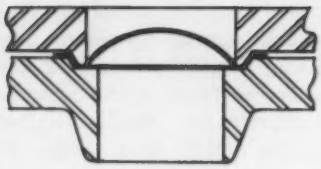
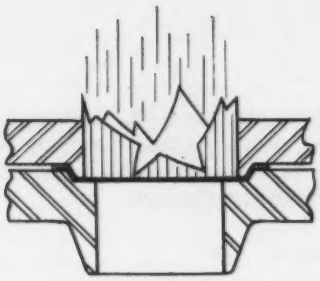


As long as pressure remains below the pre-determined point at which the dome-shaped disc will rupture, a leak tight seal is maintained.



When pressure attains the rated rupture point of the disc, instant release is provided through full orifice diameter by the outward bursting of the rupture disc.

# An Advanced Approach To Pressure Systems Design

## How To Reduce Weight Factor In Pressure Release Mechanisms

Although BS&B Safety Heads, in one form or another, have been providing over-pressure protection for closed pressure systems in numerous industries for more than 25 years, it is only recently that they have come into their own as pressure release devices for various types of airborne equipment.

Recent metallurgical and engineering developments, as well as improved manufacturing procedures, have made the BS&B Safety Head today's lightest weight, most accurately calibrated pressure release device ever developed. A typical Safety Head consists of a metal rupture membrane secured in mounting flanges. There are no moving parts.

### *Weakness A Virtue*

The rupture membrane, or disc, is a purposely designed "weak spot" in the pressure system. Over-pressure bursts it at a pre-determined set pressure rating.

Full relief area is achieved instantly. When the disc ruptures a full throated opening is provided. This outstanding feature is most advantageous in pressured systems where ignition or exothermic reaction during a process causes abnormal pressure rise in seconds or milliseconds.

... This briefly, is the function of a BS&B Safety Head as related to over-pressure protection.

### *Imagination The Only Limiting Factor*

The application and design of Safety Heads is continually being expanded. BS&B Safety Heads are serving the aircraft and missiles industries in ground, air and marine applications.

As an example... visualize the rupture disc as a seal to retain pressure in a chamber, and actuated (burst) by pressure developed within seconds or milliseconds. The pressurized fluid is thus discharged into another chamber. Here ignition may take place with contact of another fuel component. Chemical reaction may instead serve to further energize the system.

As a different application of the same basic device, the rupture disc of a Safety Head could serve as a signaling device... or to retain pressure to a pre-determined point whereupon it would then be actuated by an explosive squib or primacord.

### *Peculiarly Suited To Airborne Mechanisms*

Weight is of prime concern in airborne equipment. The smallest Safety Head now in production weighs only a fraction of an ounce. It is about the size of a large pea. In spite of its minuscule specifications it still retains all of the design features and precise operating characteristics so essential to satisfactory performance.

### *Big Or Little, High Pressure Or Low*

BS&B Safety Head sizes range from ⅛" to 44" in exposed diameter of the rupture disc. Pressure rating for the disc can be anywhere from 5 psi. to 100,000 psi. Mounting flanges and rupture disc metals can be varied over a wide selection to accommodate exposure to acids or other corrosive conditions as well as to elevated and sub-zero temperatures.

### *Hundreds Of Design Variations Possible*

If you need pressure release devices of small size and light weight for missiles and JATOS, or large sizes for ground fueling systems and engine test facilities, you should examine the advantages of using BS&B Safety Heads. Chances are there is a Safety Head of the necessary characteristics available from present designs. If not, it can be custom built to your specifications.

Here then are just a few of the reasons why BS&B Safety Heads can serve you better in many different applications...

- A pressure relief device with controlled release accuracy.
- Leak tight.
- Light weight.
- No movable parts.

*For answers to your specific questions* contact the Safety Head Division at the General Offices in Kansas City, or the BS&B Field Sales Office or Sales Agent located nearest you.

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**7500 E. 12th Street, Kansas City 26, Missouri**

With 94 per cent of the slab machined away, this complex wheel-well bulkhead retains amazing alignment.

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# LICKS DISTORTION WITH ALCOA ALUMINUM

**START WITH** a 1,268-lb slab of aluminum. Now, precision-machine it down to an unsymmetrical wheel-well bulkhead of 78 lb. (The rest is chips.) You don't need a slide rule to tell you that distortion in the finished shell will be something between a headache and a nightmare!

**NOW ADD** that the finished machining is so intricate as to be describable only by hundreds of different dimensions on the blueprints, with a bow tolerance of only 0.001 in./in., and you certainly might be forgiven for refusing the job altogether.

**R. H. BROOKS** Company, of Rockford, Illinois, did not hesitate to accept it. From Convair. It's a habit of theirs to accept challenges above and beyond the limits of valorous know-how. And they licked almost all of the problem single-handed—by methods of their own, and with machines of their own invention and design. The one remaining problem—to hold distortion within 0.125 in. in a 12-ft length—was formidable. With one supplier's product, distortion was as high as 18 in.

**BROOKS REALLY** solved *that* problem, too. Solved it by calling in Alcoa. Alcoa supplied *hand-forged, stress-relieved*, ultrasonically inspected slabs of an aluminum alloy with a temper to fulfill just such a need—T652 temper. Result: distortion virtually eliminated! The finished shell maintains alignment— though *94 per cent* of the original material has been machined away.

**IT'S GRATIFYING,** to us at Alcoa, to be privileged to cooperate with such professional fabricators of aircraft aluminum as R. H. Brooks. It's even more gratifying when they are generous enough to insist that we were of help. Perhaps we could be of help to *you*. To find out, write: Aluminum Company of America, 2032-H Alcoa Building, Pittsburgh 19, Pennsylvania.

ALCOA ALUMINUM

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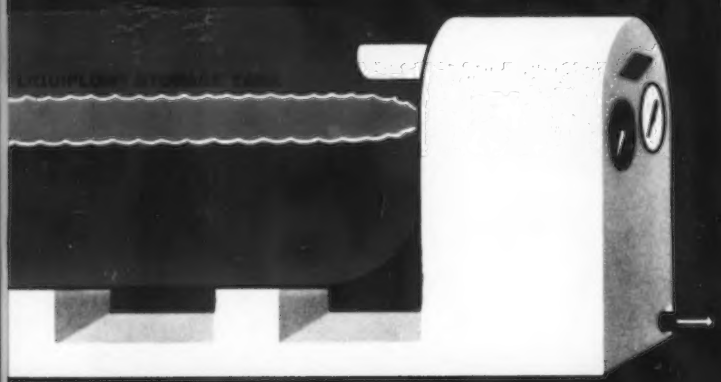
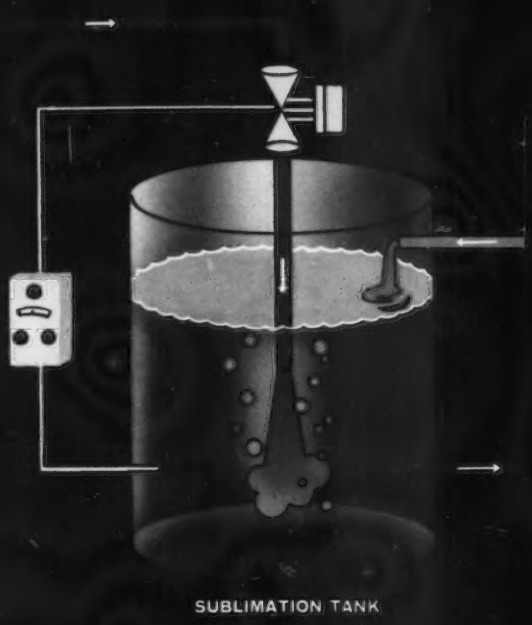
*Your Guide to the Best in Aluminum Value*

# efficient . . . low cost . . . flexible

From the smallest component parts to giant aircraft and missiles, Liquid Carbonic has the equipment . . and the answers . . . to solve your low-temperature test problems. Your Liquid application engineer is only a phone call away, ready to help you any time. He can use your existing equipment or bring his own—and whatever your problem or product, he will gladly demonstrate the fast, easy Liquid method of handling it.





SUBLIMATION TANK

OPERATIONAL UNIT

APPARATUS UNDER TEST

### LIQUID'S INDIRECT SOLVENT SYSTEM

Ideal for fuel, vacuum, hydraulic fluid or altitude testing. This unique indirect system can be adapted to existing overloaded mechanical systems, and is suitable for cooling jet engine fuels or for such human factor testing as space suits. Here's the fast, easy way to make environmental low-temperature tests—resulting in better, more dependable products. For top performance wherever normal atmospheres must be maintained, Liquid's indirect solvent system is the answer.

### MULTIPLY YOUR ENGINEERING MANPOWER!

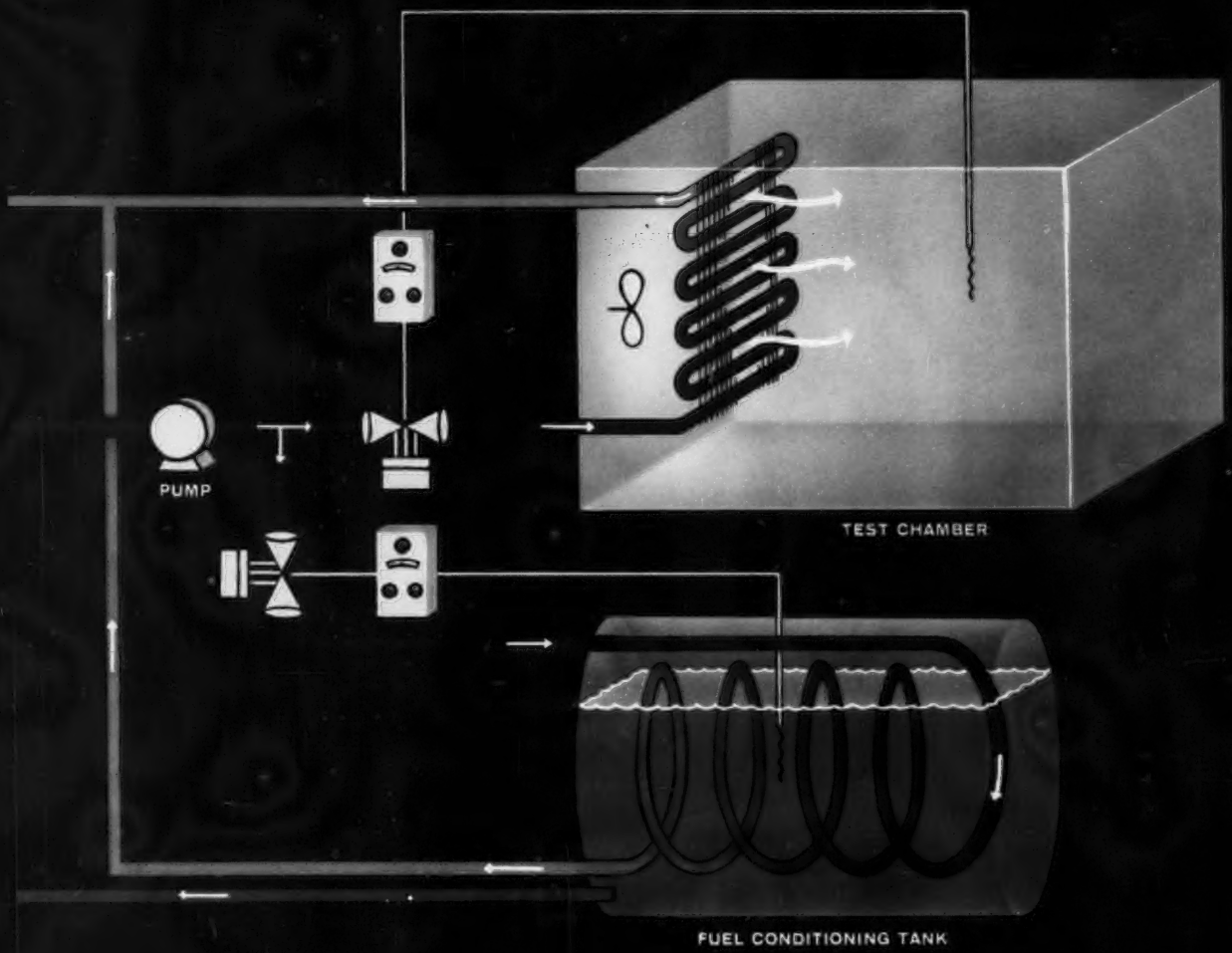
If your mechanical refrigeration unit is taking 8-10 hours to pull down from 200° F. to —65° F., $CO_2$ will do the same job in 8-10 minutes! Liquid's direct $CO_2$ injection pulldown to mechanical hold actually increases productive engineering time. Here is the ideal unit for your "fast-drop" tests to save both time and money.

Ask your Liquid Carbonic application engineer how *you* can save with a fast, improvised test on *your* product! Contact him today for a demonstration with this portable $CO_2$ testing equipment right in your own plant or laboratory at no obligation.

**WORLD'S LARGEST PRODUCER OF $CO_2$**

A Major Producer of Compressed Gases: Oxygen, Acetylene, Nitrogen, Hydrogen, Argon, Carbon Dioxide, Nitrous Oxide, Helium and Various Gas Mixtures.

# environmental testing with $CO_2$




**DIRECT INJECTION**

You can have unlimited refrigeration capacity with only a temperature controller and valve, chamber, and low-cost $CO_2$. In fact, for one ton of refrigeration per hour, you need only approximately one pound of $CO_2$ per minute! This handy unit is inexpensive and easy to operate, gives immediate pulldown to −109° F., and lends itself to simple automation.

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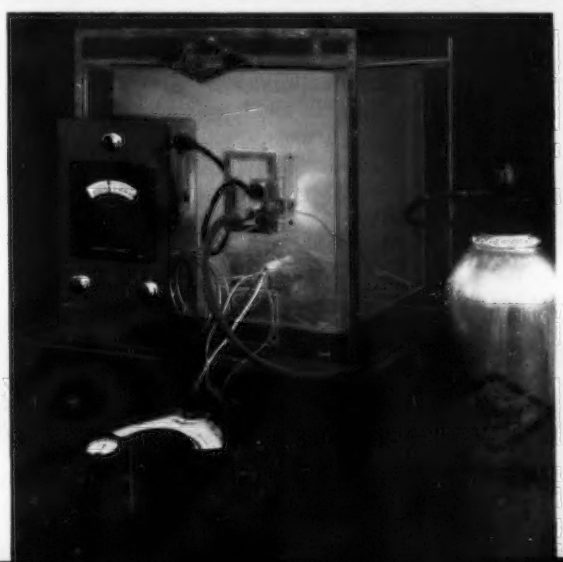
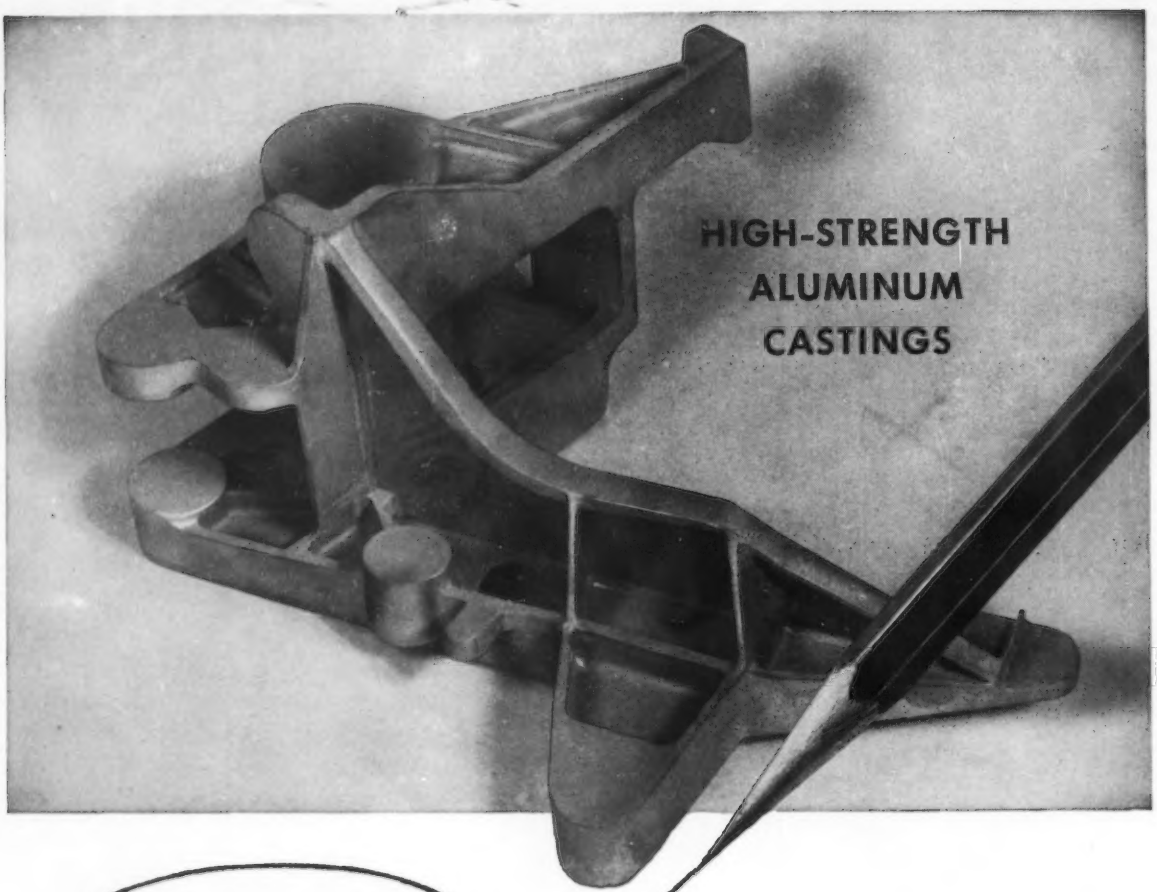





## NOW! SPECIFY MIL-C-21180(Aer) TO GUARANTEE 42,000 psi

Now you can specify MIL-C-21180(Aer) for high-strength aluminum castings, and eliminate approval delays.

High-strength aluminum castings meeting the specifications of MIL-C-21180(Aer) are produced by American Brake Shoe Company in Ductaluminum 356T and Ductaluminum 356S. These castings provide guaranteed* mechanical properties in highly stressed areas specified by the design engineer. Greater design freedom, improved production economy, and complete service reliability result.

Brake Shoe produces sand, permanent mold, and plaster mold castings—from a few ounces to 500 pounds—in both high-strength and standard alloys. Government certified heat treat, Zyglo, and X-ray. Send drawings of your problem parts and let our engineers show how critical, hard-to-make designs can be produced as high-strength aluminum castings. Delivery from our plant at Mahwah, New Jersey, or our Gaines Works at Rivera, Calif.

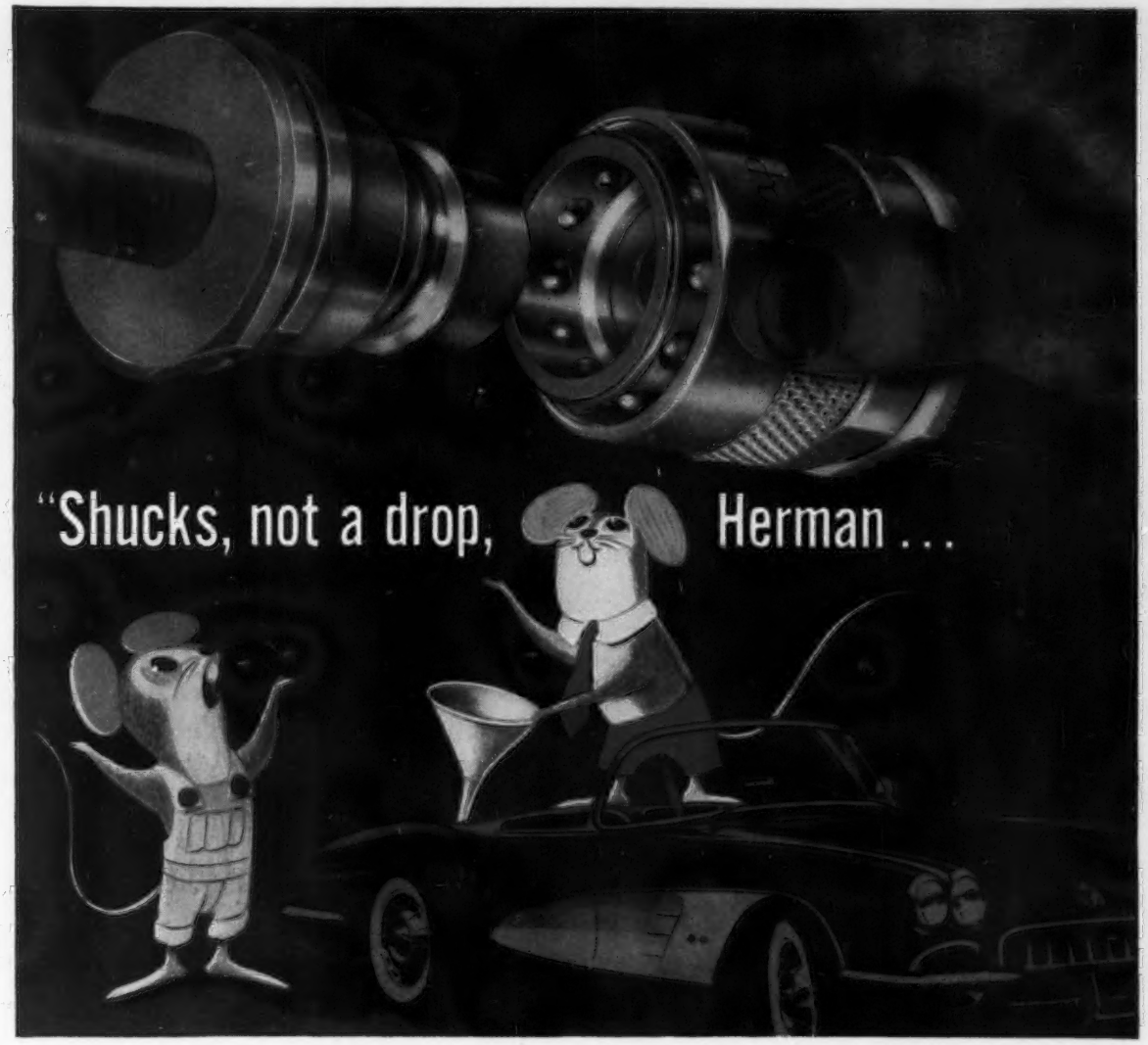
**Guaranteed Properties in highly stressed areas.*

| | T.S., psi | Y.S., psi | %El. |
|---|---|---|---|
| Ductaluminum 356T | 38,000 | 28,000 | 6 |
| Ductaluminum 356S | 42,000 | 35,000 | 3 |

Other grades available to all military specifications.

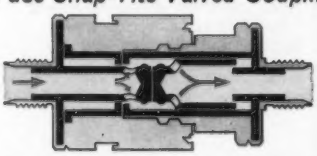
AMERICAN Brake Shoe COMPANY

LIGHT METALS DEPARTMENT
MAHWAH, NEW JERSEY

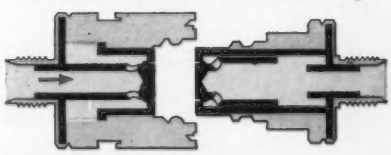



## . . . it's a no-spill valved coupling by Snap-Tite!"

*To use Snap-Tite Valved Coupling:*



CONNECT—Full flow instantly



DISCONNECT—Stop flow instantly

The 15 Series valved coupling automatically snaps off the flow of the most volatile fluids when disconnected—with no leakage.

Snap-Tite's 15 Series valved coupling contains valves in both sections. Thus, the only fluid lost is that which clings to the outer metal surfaces. This coupling meets military specifications and can be used with fuels and other fluids to 3000 psi working pressure and 400°F. Sizes: ¼", ½", ¾", 1" in 6061T6 aluminum anodized; ⅜" in steel (electroless nickel plated), and 6061T6 aluminum.

Snap-Tite can provide the right valved coupling—with quick off-on action wherever coupling or shut-off is required—for most any use, most any fluid.

*For more information, write for Snap-Tite Catalog #15. Snap-Tite representatives in all principal cities.*

Snap-Tite

UNION CITY, PA.

ST-59-03

over 1200 vendors of raw materials, and off-the-shelf equipment supply B-58. Materials are critical as shown in the following account of the search for "adequate" fire curtain material.

# fire curtain

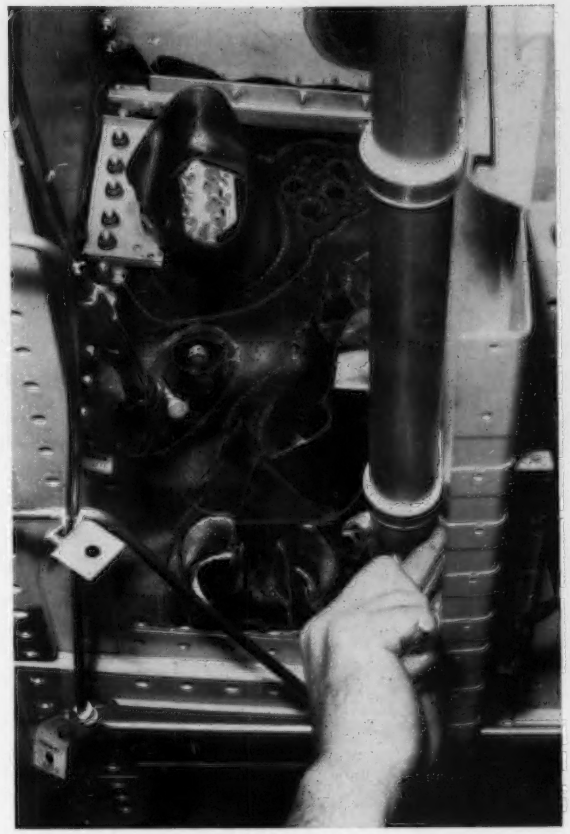
## air-tight 'boxes' in B-58 wings formed by Inconel-reinforced asbestos fabric, coated on both sides with Viton A

"Containment" plays an important part in reducing the fire hazard in aircraft. As a part of preventive design, fire curtains are used to compartmentalize large areas that might otherwise give fire an unnecessary advantage once outbreak occurs.

In Convair's B-58 Hustler, an equipment tunnel runs the full span of each wing. The tunnel houses lines for air conditioning, hydraulics, fuel, and electronic equipment. This passageway must be comparmentalized to keep air flow to a minimum.

The material used for bulkheads need not add to the structural integrity of the wing; but, in compliance with Convair specifications, material should:

Rolls of Viton A-coated fabric have fire curtain patterns applied by spraying paint on perforated stencil.



Curtain assembly is secured in wing equipment-tunnel with 3/16 in. bolts. Standard AN clamps secure sleeves to equipment that must pass through curtain (arrow).

# for Hustler

by John P. Kushnerick

- Resist flame penetration for 5 min at 1800°F.
- Resist cracking after 96-hr aging at 500°F.
- Resist cracking (per ASTM D736-54T) after aging 5 hr at —40°F.
- Weigh 3.25 lb/sq yd max.
- Resist environments of Oronite 8515 silicate ester, JP-4 fuel, ozone, and electrical corona.

## Material for the Job

The material selected is a wire-reinforced asbestos fabric coated with Viton A on both sides. Raybestos-Manhattan Inc. is the supplier.

The wire used is Inconel, asbestos is ASTM Grade AAA and the Viton A coating is a fluoroeslastomer. (See "fluoroelastomer." AMM, June 1958). No other material has met test requirements.

*continued on next page*

Individual pieces are machine-stitched into complete unit with asbestos-coated Inconel wire.

Brush-coat of liquid Viton A is applied to all cut and all stitched ends. This prevents "wicking" of fluids.

# fire curtain . . . continued

Convair would prefer that materials used for fire curtains in B-58 meet specifications, with oven aging temperature raised to 1000°F for 96 hr, and low temperature aging lowered to −65°F for 5 hr. No material available meets these requirements.

### Fabricating and Installing

The Viton A-coated material in use is received in rolls of 36 ±½ in. width. It is unrolled on large work tables and patterns for the sleeves and collars that must be affixed to the fire curtain are applied to the fabric by spraying white paint over a perforated stencil.

Pieces are cut by hand and machine stitched with cotton thread. After inspection, they are permanently stitched with asbestos-coated inconel-wire thread.

The assembled curtain is brush-coated with liquid Viton A on all cut and all stitched edges. This prevents "wicking" of combustible fluids by the asbestos.

The fire curtains are affixed to the equipment tunnel with standard 3/16 in. bolts. Equipment lines are pushed through their respective openings and properly positioned. Dirt and grease are removed by a solvent wiping, and clamps are applied to seal each line tightly to a sleeve on the fire curtain.

### Specific Tests

The testing cycle on flexible fire curtain materials is intended to approximate those environments encountered on normal missions and still provide reasonable safety. Weight economy is a major factor in procurement where two materials are near equal in other respects.

Flame resistance and after glow is performed after conditioning specimen to 120°F and 65 per cent relative humidity for 24 hr. Specimen is inserted into Meker burner flame and hotside temperature measured at 1800 ±100°F. After 20 sec exposure, afterglow should not exceed 10 sec. Material must also resist flame penetration for 5 min in same test.

Low temperature brittleness test is performed in accordance with ASTM D736-54T. Exposure prior to test is for 5 hr at —40°F. (Convair still seeks a material to pass test at −65°F.)

Tensile strength of the fabric when tested in accordance with ASTM D751-52T should have minimum strength of 200 lb/in. warp, and 100 lb/in. fill. Thickness of fabric should not exceed 0.075 in.

Absorption and deterioration of fabric when tested in various liquids should not exceed the following:

| | Weight Change % |
|---|---|
| Hydrocarbon (Type III) Spec MIL-S-3136A | plus 10 minus 2 |
| Lubricating Oil, synthetic base Spec MIL-L-7808C | plus 18 minus 2 |
| Hydraulic fluid, synthetic base Spec MIL-H-8446A | plus 18 minus 2 |
| Fuel, JP-4 Spec MIL-F-5624C | plus 10 minus 2 |

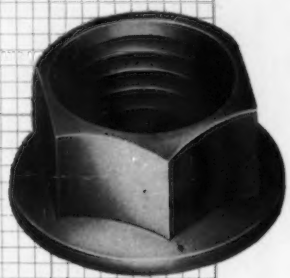
✦

*Again...*

# ESNA gives the design decision to the engineer

*If your major consideration is . . .*

## . . . WEIGHT REDUCTION

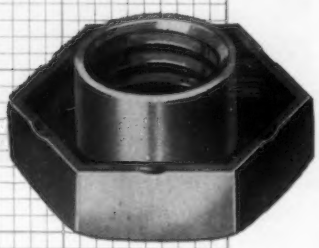


Type LH3324 (160,000 psi)

**THIS NEW DESIGN** is ESNA's recommendation for applications where space and weight reduction are primary needs. Meets MIL-N-25027; reduced wrenching dimensions permit more center-line efficient bolt design; wrench heights carefully engineered to assure satisfactory assembly line performance. Materials: carbon steel, AMS6304 alloy steel and A286 stainless steel.

| wt in lbs per 1000 | Screw Size # 4 | # 6 | # 8 | # 10 | ¼" | 5/16" | 3/8" | tensile rating |
|---|---|---|---|---|---|---|---|---|
| LH3324 | .2 | .6 | 1.3 | 1.4 | 2.9 | 5.4 | 7.3 | 160,000 psi |
| NAS679 | .9 | 1.7 | 2.4 | 2.6 | 4.6 | 6.4 | 8.6 | 140,000 psi |
| AN365 | 1.4 | 2.6 | 4.2 | 5.0 | 9.0 | 12.0 | 18.0 | 140,000 psi |

## . . . USE OF NAS STANDARD HARDWARE



Type LHTE-TM (NAS 679 140,000 psi)

This complete line of low-height, lightweight NAS 679 hex nuts has been designed and produced to ESNA's exacting quality standards. Qualified to MIL-N-25027. External-internal wrenching surfaces for easy installation in limited access areas. Sizes 4-40 through 7/16-20. Alloy steel for temperatures to 550°F; A286 stainless steel for temperatures to 900°F and nonmagnetic applications.

*ESNA offers a complete line of ALL NAS types of self-locking nuts, including standard and miniature anchors, floaters and gang channels.*

## . . . ULTRA-HIGH TENSILE AND FATIGUE PERFORMANCE

Type LH3393 (220,000 psi)

Specify types LH 3393 and LHEB 220 for the utmost in high tensile and fatigue-life performance. Highest strength-to-weight of any available double hex design. Cold-formed from alloy steels; sizes ¼-28 thru 1". For use at temperatures to 550°F.

*Three other lightweight 12 point nut series are available in several tensile capacities and materials for service at temperatures to 1200°F.*

*Fit the fastener to the application from the only complete line of self-locking fasteners*

**ELASTIC STOP NUT CORPORATION OF AMERICA**

**Dept. S36-898, Elastic Stop Nut Corporation of America**
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**Please send me the following free fastening information:**

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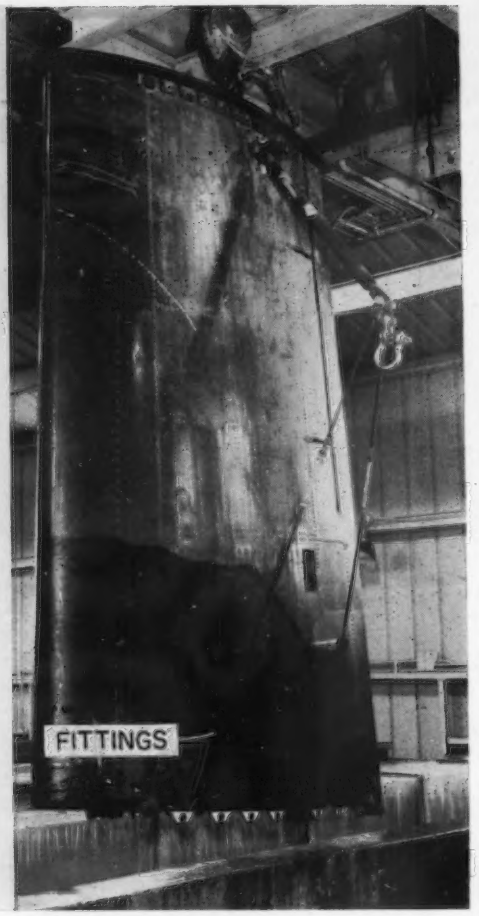
# cut costs with chem-milling

## how Grumman saved $7192/unit reworking wing-master tools for S2F-1, –3

by LeRoy T. Jaret, staff engineer
manufacturing engineering div.
Grumman Aircraft Eng. Corp.




Tooling used to hold, and dip S2F wing-masters in sealing and etching solutions is shown.

Cutting costs is everyone's job. It is an endless job. Constantly slicing away at production costs puts the gloss of professionalism on a process. It makes the process more than a "rough blank."

At Grumman, cost cutting potential was recognized in the master tooling used for checking S2F-series wing-center sections. As the dash-three model went into production, dash-one models had not been phased out. Wing fitting design had been changed slightly on the later model.

Manufacturing Engineering reasoned that with modification to existing dash-one tooling it could double for both aircraft. The problem was to reduce by 0.125 in., the over-all thickness of 16 wing-lock fittings. That is, to remove 0.062 in. from each side of the 0.500-in. members. Tolerance requirements were $\pm$ 0.002 in., at a surface finish of 100 to 200 RMS. Since the master tool was already perfectly aligned, the fittings were not to be removed from the master.

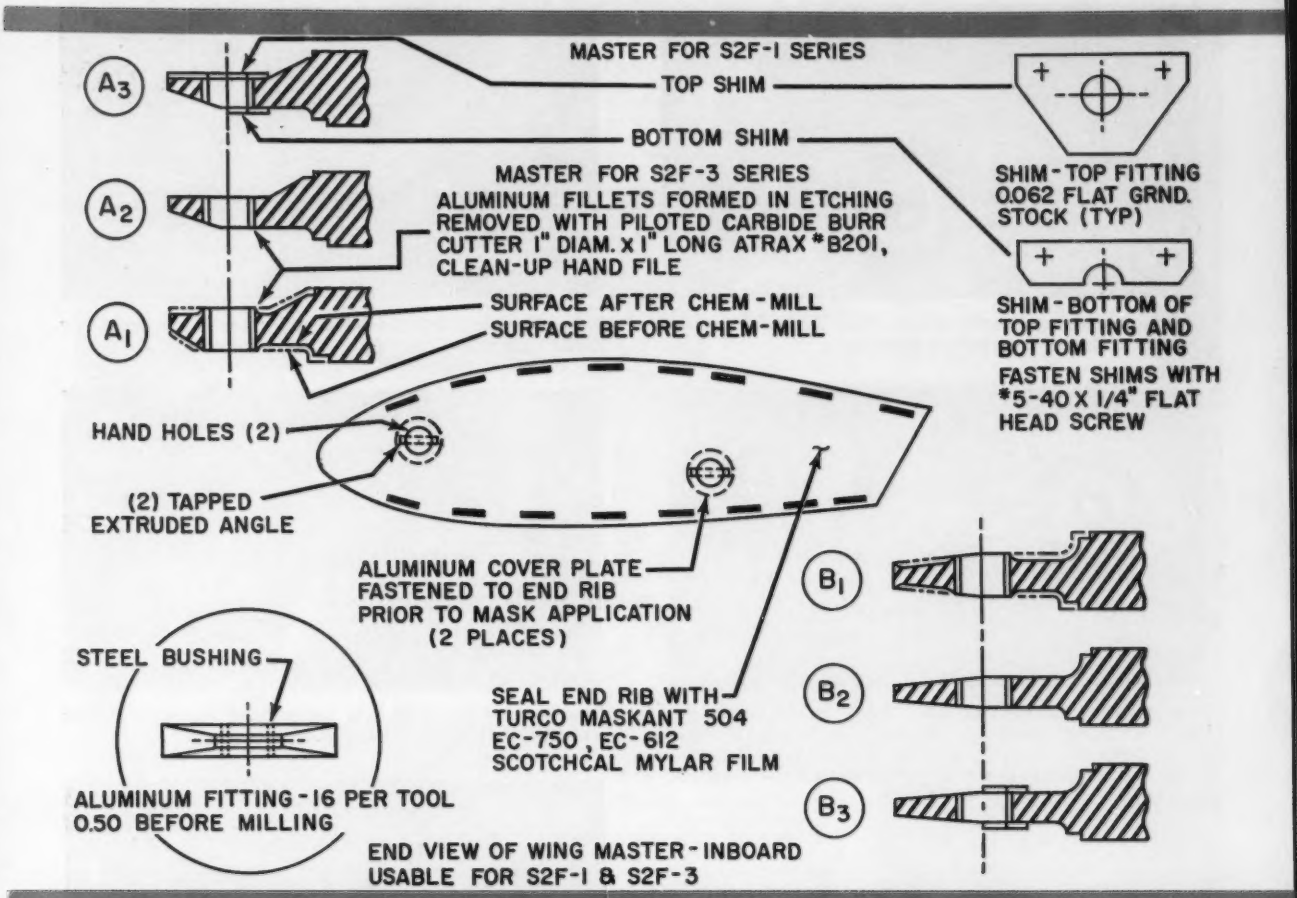
### The Saving, $7192.42

A detailed cost-study of machine milling vs. chemical milling showed a $7192.42 saving could be realized by the latter method. Milling time would take 4 wk vs. 11 wk. In addition, some new facts were destined to be gathered about masking, and new potentials of chemical/milling realized.

### Attacking the Problem

The parts to be milled were aluminum alloy "tongues" along the top and bottom of the folding wing airfoil profile. These "tongues" mate with female slots when the wing is spread. In operation, locking pins are inserted through aligned holes in the male and female members. These holes are lined with steel bushings.

The chemical milling process was evaluated on fittings rejected in the initial fabrication of the master because of machining defects. These samples were completely masked with a neoprene base material. Maskant was then re-


MASTER FOR S2F-1 SERIES
TOP SHIM
BOTTOM SHIM
MASTER FOR S2F-3 SERIES
ALUMINUM FILLETS FORMED IN ETCHING REMOVED WITH PILOTED CARBIDE BURR CUTTER 1" DIAM. x 1" LONG ATRAX #B201, CLEAN-UP HAND FILE
SURFACE AFTER CHEM-MILL
SURFACE BEFORE CHEM-MILL
A3
A2
A1
SHIM-TOP FITTING 0.062 FLAT GRND. STOCK (TYP)
SHIM-BOTTOM OF TOP FITTING AND BOTTOM FITTING
FASTEN SHIMS WITH #5-40 X 1/4" FLAT HEAD SCREW
HAND HOLES (2)
(2) TAPPED EXTRUDED ANGLE
ALUMINUM COVER PLATE FASTENED TO END RIB PRIOR TO MASK APPLICATION (2 PLACES)
STEEL BUSHING
SEAL END RIB WITH TURCO MASKANT 504 EC-750, EC-612 SCOTCHCAL MYLAR FILM
ALUMINUM FITTING - 16 PER TOOL 0.50 BEFORE MILLING
B1
B2
B3
END VIEW OF WING MASTER - INBOARD USABLE FOR S2F-1 & S2F-3

DETAILS OF CHEM-MILLING SEQUENCE

moved from all areas except:

- Steel bushing.
- Extreme inboard end of the fitting, thus preserving the mastered point.

Samples were etched in the production caustic tanks with these results:

- Thickness tolerance, ± 0.002 in.
- Surface finish, 150 to 175 RMS.
- Aluminum-to-steel contact area was unaffected.

### Sealing the Wing Section

One problem remaining was the sealing and handling of the master wing during etching. Intricate design required the use of a combination of 4 sealing compounds. All parts were wiped with methyl-ethyl ketone, and methyl-isobutyl ketone. Then:

(1) Scotchkal Mylar film was used for backing to receive other sealants on large openings.

(2) Minnesota Mining and Mfg. products, EC-750 and EC-612, were used to seal areas not readily accessible.

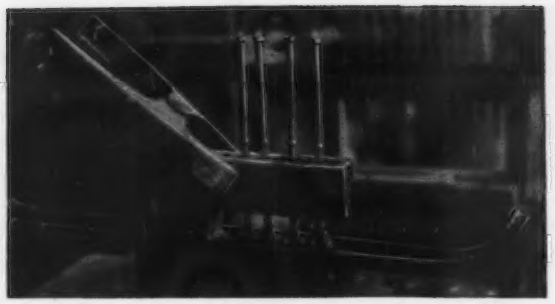
(3) Finally, neoprene base Turco 504, was applied by the flow coat process. Seven coats were applied, with 30-min drying time between coats.

(4) Etching was accomplished by 1-hr dip in caustic bath (190 ± 2°F).

Elimination of non-etch alkali and deoxidizing cleaning cycle were a first for Grumman. Fear of master distortion was reason for eliminating heat cure (225°F for 75 min) of Turco 504 maskant.

◆

Operator applying Special Handy Flux Type B-1 to components of de-icer tube before brazing.



Here, four de-icer assemblies in jig are being brazed by induction heat.

First step in brazing manifold. Operator applies Special Handy Flux Type B-1 to joint area prior to hand brazing. B-1 Flux is particularly effective in removing refractory oxides such as those formed in stainless steels and carbides.

Operator preheats joint area before hand feeding Handy & Harman silver alloy Braze 541.

Here, two different parts are being brazed. Operator in foreground hand feeds alloy on aircraft manifold joint while operator in background brazes nipple on hydraulic oil filter. Gas-air hand torches are used in both cases.

# Here's how you can get uncompromising **JOINT STRENGTH** at **LOW-COST...** Handy & Harman **SILVER BRAZING**

The first requisite for virtually any aircraft part is unimpaired strength. Jerden Manufacturing Company, Indianapolis, makes a number of tubular aircraft parts and components and each of them must pass rigid tests before acceptance. Three of the components are a hydraulic aircraft filter, a manifold assembly and a de-icing tube. Tubes and fittings are 410 and 321 stainless steel, brazed with Handy & Harman silver alloy Braze 541 (formerly 4772).

Handy & Harman's Braze 541 is specifically formulated for brazing stainless steels. It has a high flow point (1575°F), and its excellent strength at elevated operating temperatures especially recommends it for many aircraft component applications. Braze 541 is a "tailor-made" brazing alloy, designed to do a specific joining job and do it particularly well. It is an example of Handy & Harman's ability to supply a specific alloy to fit a specific need, a service that remains constantly available to you.

You may find that your metal joining requirements are more or less special or you may not be fully aware of what you require. In any case, we invite you to consult us about what you are joining and *would like to join better*. We may be able to help you from many points of view: economy, joint strength, conductivity, ease of production and many others.

**GET THE FACTS**

Technical Bulletins T-1 and T-2 give the general characteristics of silver brazing alloys plus the compositions, melt and flow points of 32 separate alloys. Write for your copies.

***Your NO. 1 Source of Supply and Authority on Brazing Alloys***

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FABRICEL DIVISION — Forming, contouring and fabricating aluminum, fiberglass and metal for aircraft, missiles, electronics, and ground support equipment. Completed rocket, shown with trailer.
LEFCO PRODUCTS INC.—Specialized plastics manufacturing of fluorocarbon plastic Teflon—also kel-f, nylon and polyvinyl—standard and custom sizes and shapes.
ADOR CORPORATION — Prefabricated construction units to shelter ground support personnel and equipment. Complete prefabricated walls, doors, and windows.

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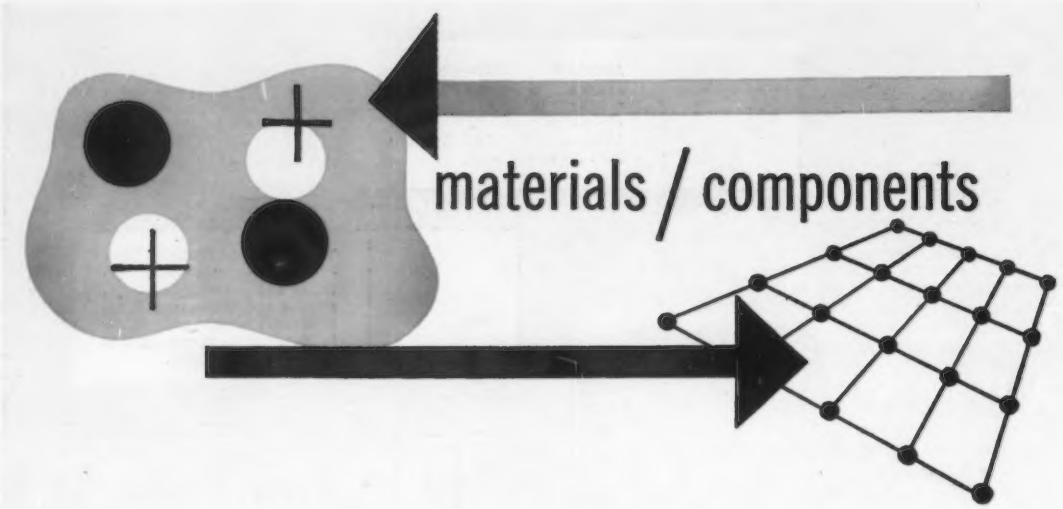
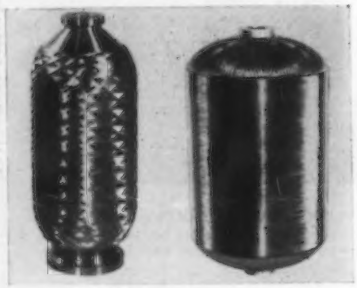



## ROCKET CASES FORMED BY WIRE WRAPPING

Several years of research are behind wire wrapped rocket cases now in production at Bendix. Consistently high strength,



with lower weight and lower cost, is claimed over those being produced by other methods.

A number of strands of very high-strength small-diameter wire are formed into a tape, using partially cured high adhesive epoxy resin to provide good handling characteristics. A mathematically determined wrap pattern provides uniform stress on each wire. A specially designed wrapping machine winds the multi-wire tape over a mandrel. Spherical, elliptical, conical and other end configurations are possible. Wrapping-in the necessary fittings and skirt is standard procedure.

After wrapping is completed, the case receives a final cure. Test values are equivalent to a hoop stress of 355,000 psi in a homogeneous case.

*Products Div.*
*Bendix Aviation Corp.*

**Circle 101 on postcard for more data**

## HI-ALLOYS AVAILABLE THINNER AND WIDER

Haynes Stellite has announced the availability of several high-temperature alloys in wider cold rolled thin-gage sheets than previously available. Sheets 0.010 in. thick, 36 in. wide, and 96 in. long are now being rolled as a result of recent refinements in technique at the company's expanding wrought alloy facilities in Kokomo, Ind.

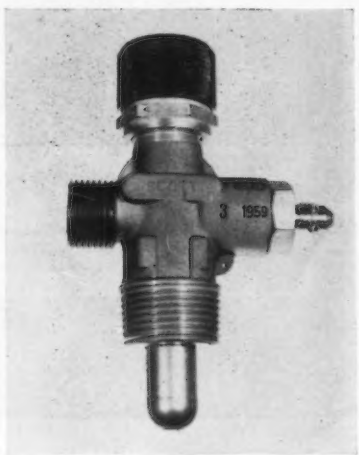
Alloys currently available in this form are "Haynes" alloy No. 25, "Multimet" alloy, "Hastelloy" alloy R-235, "Hastelloy" alloy X, and General Electric's "René 41" alloy. These alloys are among the leading materials in the field of high-temperature metallurgy.

*Haynes Stellite Corp.*

**Circle 102 on postcard for more data**

## TAPERED VALVE INSURES SLOW OPENING FOR $O_2$

Slow-opening valve prevents "ram effect" when oxygen



is suddenly released from a high-pressure container. A specially tapered valve and seat arrangement insures the gradual opening.

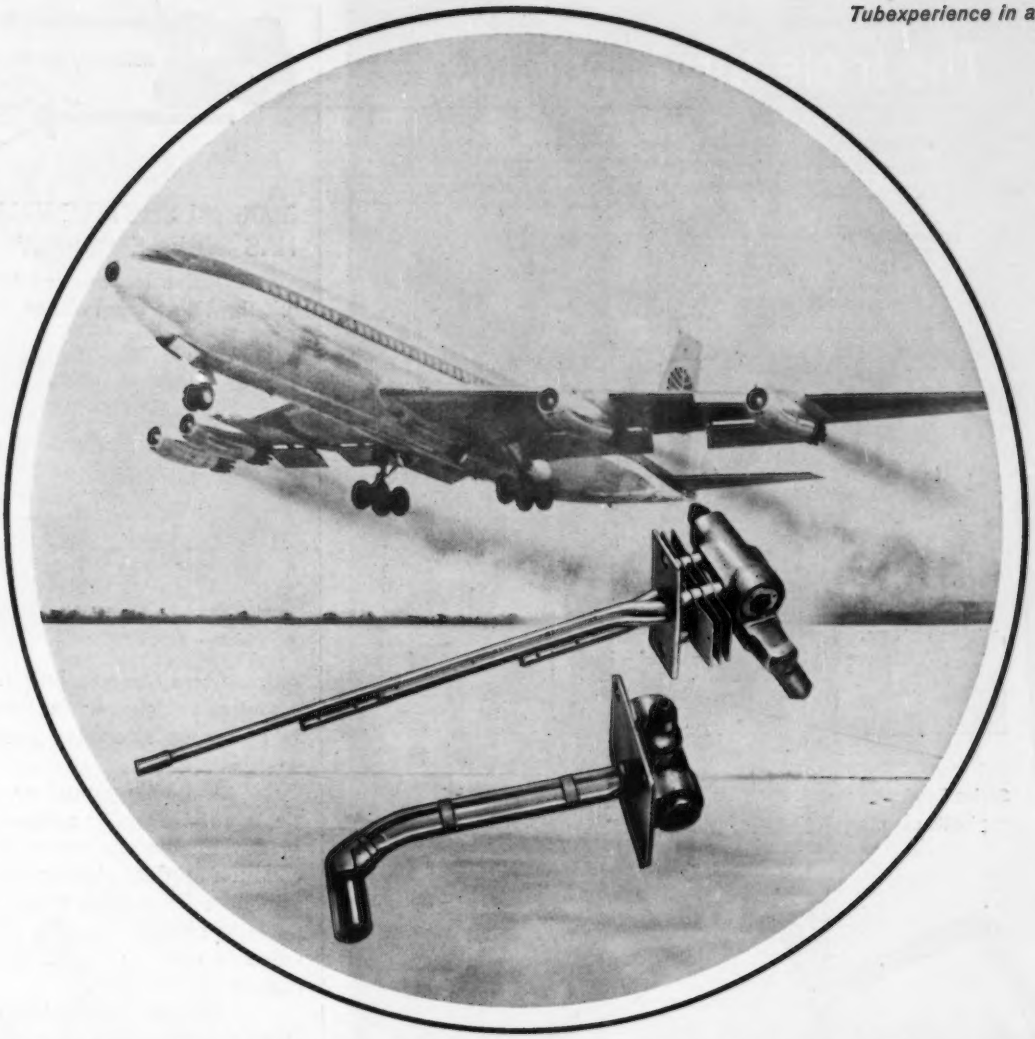
Designed for airline use, this valve incorporates a heavy, metal pressure-gage case. The gage is flush mounted in the valve-body forging to make it less vulnerable to damage.

*Scott Aviation Corp.*

**Circle 103 on postcard for more data**

*continued on page* 48

*Tubexperience in action*



# Jet Engine Hot Spots Torture Superior Super Alloy Tubing

## *Tubing must not take a permanent set or rupture*

Temperatures up to 1800°F torture the Superior Super Alloy Tubing used as fuel lines to spray nozzles and as spray bars for afterburners in a current model jet engine. High oxidation resistance and strength at elevated temperatures are a must. But of even greater importance is the ability of the tubing to resist taking a permanent set or rupturing under the high stresses developed in service.

Parker Aircraft Co.'s Engine Accessories Division, Cleveland, with our cooperation, chose the analyses. Service conditions and fabrication requirements limited them to two: N-155,* incl. approx. 21% chromium, 20% nickel, 20% cobalt, balance iron—plus columbium; Haynes No. 25,† incl. approx. 20% chromium, 10% nickel, 15% tungsten, balance cobalt. Both have excellent oxidation resistance, stress rupture characteristics, high strength at elevated temperatures.

N-155 tubing, as produced by Superior, was selected for the fuel lines because it is amenable to bending and shaping without cracking and is easier to braze. It is also used for the spray bars operating in temperatures under 1300°F because it is easier to drill. When higher temperatures are encountered by spray bars, Haynes No. 25 tubing is used.

Superior Super Alloy Tubing, in a wide range of standard and special analyses, in ODs ranging from .012 through 1.125, is available in both Seamless and WELDRAWN® types. Bulletin 70 describes them in detail. Write us for your copy. Superior Tube Company, 2053 Germantown Ave., Norristown, Pa.

*Reg. U.S. Patent Office, Union Carbide Corp.
†Reg. U.S. Patent Office, Haynes Stellite Co.

**Superior Tube**

**The big name in small tubing**
**NORRISTOWN, PA.**

*All analyses .010 in. to ⅝ in. OD—certain analyses in light walls up to 2½ in. OD*

West Coast: Pacific Tube Company, Los Angeles, California • FIRST STEEL TUBE MILL IN THE WEST

# The triple-threat pot line

Pick the pot to suit your system . . .
be it esoteric or plebeian . . . from the
triumvirates of HELIPOT single-turns
(1/2" to 3" dia.) or multi-turns
(7/8" to 3 5/16" dia.).
No need to overspecify . . .
pay only for what you need!
Par exemple? The three HELIPOT
1 7/16" single-turns,
each the leader in its own milieu:

to 80°C

Series 5400 with plastic case

to 125°C

all-metal Series 5410

to 150°C

all-metal Series 5420

Pay only for what you need . . .
in single-turn
and multi-turn precision pots.
You'll find your circuit solution . . .
for a system hot or cold . . .
in Data File F82.

Beckman® / Helipot

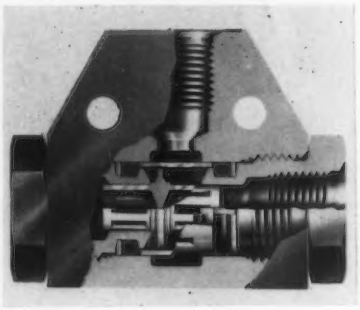
Helipot Division of Beckman Instruments, Inc.
Fullerton, California
Engineering representatives in 29 cities

potentiometers · dials · delay lines · expanded scale meters · servomotors · breadboard parts


materials / components

## 3000 psi SHUTTLE VALVE HAS DOUBLE POPPET

Valve is designed to permit fluid flow from either of two



sources to a common outlet. Automatic switchover is possible when using alternate pressure sources.

A double poppet or shuttle is automatically actuated by pressure from one source to the common outlet, closing off the alternate inlet dead tight. This permits ultilization of a shuttle valve in circuits where leakage cannot be tolerated.

Typical applications include preflight checkout of missile transducers and pressure switches, and an automatic switchover action when alternate pressure sources are used.

The valve is rated for 0-3000 psi service. It is available in aluminum and stainless steel.

*James, Pond & Clark*

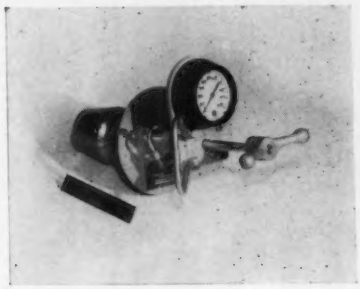
**Circle 104 on postcard for more data**

## GROUND CHECK INSURES IN-FLIGHT FUELING

Developed to replace a heavier, more costly model, the new aluminum, portable, MA-2 Pull-off Tester is used for rapid ground checking of engaging and disengaging forces between aerial refueling equipment.

This testing instrument

is manually inserted into the tanker aircraft's reception coup-



ling (simulating receiver aircraft's probe entry) to check the toggle tension through a closed hydraulic circuit.

*Flight Refueling Inc.*

Circle 105 on postcard for more data

## MODULAR FUEL PUMPS ALLOW WIDE OUTPUTS

Two centrifugal fuel pumps utilize a modular construction and allow combinations which provide performance from 10 to 250 gpm. Different capacities are obtained by modification of impeller and motor stack length. Customized

mounting can be provided.

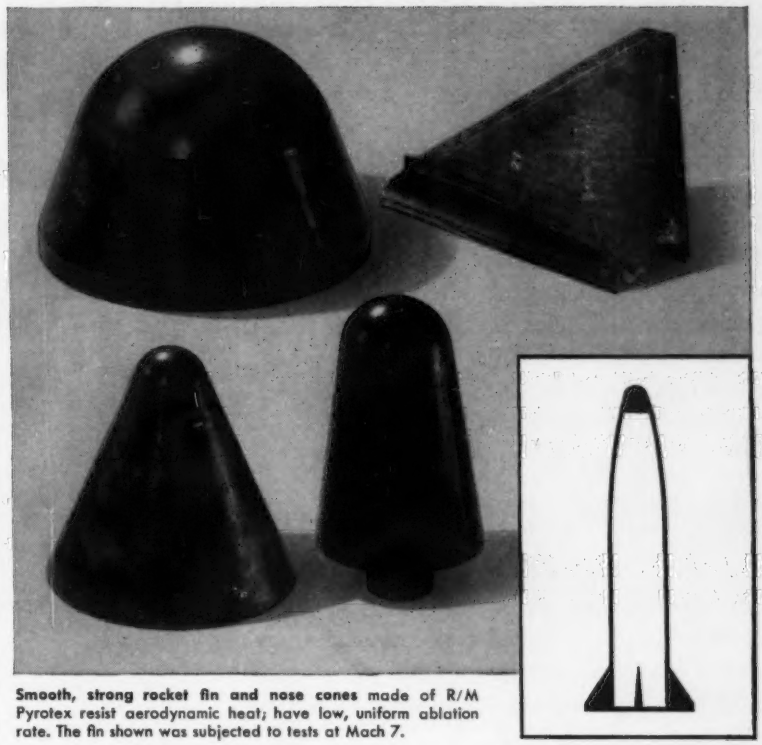
Pumps are available in either AC motor drive or hydraulic motor drive. Hydraulic motor is gear type with high speed capabilities making it excellent driver for the centrifugal pump.

*Adel Precision Products Div. of General Metals Corp.*

Circle 106 on postcard for more data


# R/M PYROTEX® REINFORCED PLASTICS ...DEVELOPED TO ENDURE THE FIERY REALM OF THE ROCKET

**Light, strong, heat resistant . . . for low-cost, precision fabricated rocket parts— both structural and aerodynamic**



**Smooth, strong rocket fin and nose cones** made of R/M Pyrotex resist aerodynamic heat; have low, uniform ablation rate. The fin shown was subjected to tests at Mach 7.

Looking for a material that will withstand the elevated temperatures generated by missiles and rockets—internally from burning propellants, externally from aerodynamic heating? Must this material have good insulation and thermal properties, chemical and water resistance, and take a smooth finish? If so, one of R/M's family of Pyrotex reinforced plastics may be the solution to your problem.

The many outstanding thermal and structural features of R/M Pyrotex have led to its use on almost every U.S. missile. It has been fabricated into parts such as nose cones, fins, igniter tubes, rocket throats and silver traps. Its exceptionally good dimensional stability makes possible mass production to precision standards. And it is low in cost. Write for additional information.

RM

**RAYBESTOS-MANHATTAN, INC.**

**REINFORCED PLASTICS DEPARTMENT, Manheim, Pa.**

FACTORIES: Manheim, Pa.; Bridgeport, Conn.; Paramount, Calif.; No. Charleston, S.C.; Passaic, N.J.; Neenah, Wis.; Crawfordsville, Ind.; Peterborough, Ontario, Canada

RAYBESTOS-MANHATTAN, INC., Asbestos Textiles • Laundry Pads and Covers • Engineered Plastics • Mechanical Packings • Sintered Metal Products • Industrial Rubber • Rubber Covered Equipment • Brake Linings Brake Blocks • Abrasive and Diamond Wheels • Clutch Facings • Industrial Adhesives • Bowling Balls

# NEW CP PORTABLE BROACH GUN CONVERTS ROUND PILOT HOLES TO

*square*

*hex*

*oval*

*splined*

*keyed*

# SHAPES

You take the tool to the work with the CP Portable Broach Gun . . . a completely new technique in broaching. Operation is fast and simple. Broach is inserted in pilot hole and with a squeeze of the trigger the hole is formed or finished in a single, swift operation. Set-up time is eliminated since no jigs, fixtures or templates are required in most applications. Drilled, punched or cast holes can be finished to round, square, hexagon, oval, or irregular shapes in any work area. Angle Broach Puller, for close quarters, is also available.

The broach pulls a clean hole every time, and leaves it "mirror" finished. Hole sizing accuracy can be ±.0002. Unskilled operators can consistently produce accurate holes with minimum training time.

CP Power Cell weighs only 58 pounds, operates on shop air lines, furnishes oil pressure up to 7,000 psi. Easily moved from job to job anywhere in the plant. Also powers hydraulic riveters, squeezers, punches.

**Chicago Pneumatic**

*8 East 44th Street, New York 17, N. Y.*

Pneumatic Tools • Air Compressors • Electric Tools • Diesel Engines
Rock Drills • Hydraulic Tools • Vacuum Pumps • Aviation Accessories

*Portable, air-powered, hydraulic power cell weighs only 58 pounds.*

**Chicago Pneumatic Tool Co., 8 East 44th St., New York 17, N.Y.**

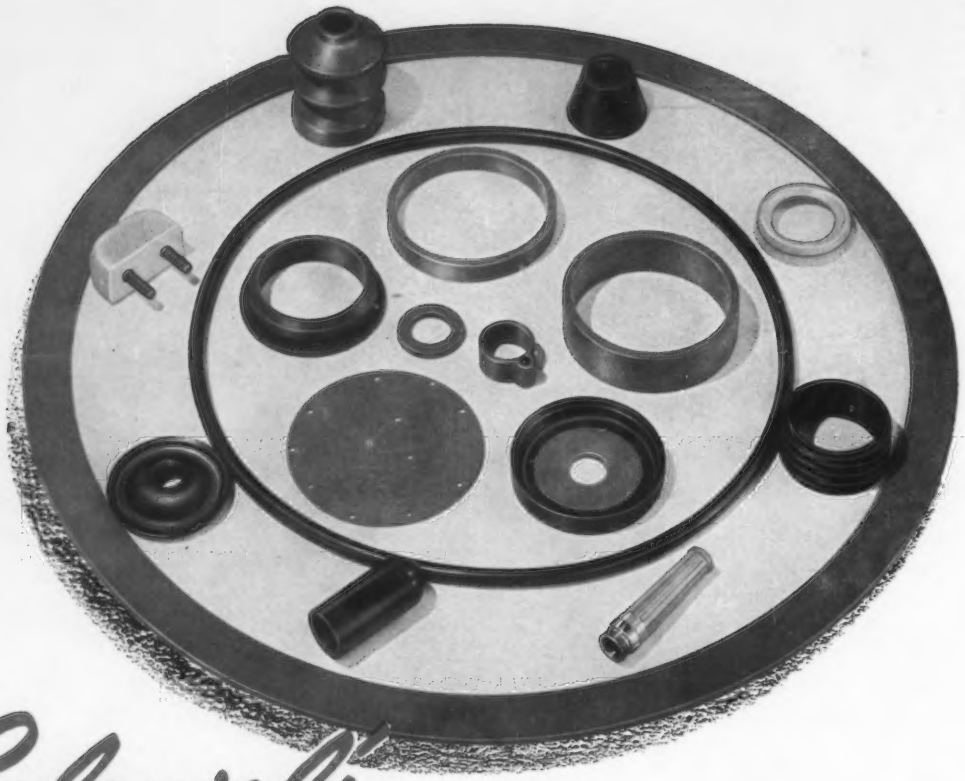
I'm interested in broaching holes. Please send me a copy of Bulletin 581-2. Address Dept. B-8.

Name _____ Title _____

Company _____

Address _____

City _____ Zone _____ State _____



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## "SILICOL"® SILICONE RUBBER

### *can improve your product and simplify fabrication problems*

★ ***ANY MOLDED SHAPE***

★ ***ANY COMPOUND FORMULATION***

Colonial Rubber has a long record of achievement in using the unique properties of silicone rubber to meet "tough service" applications in all types of manufacturing. Particularly outstanding are the many special compounds our chemists have formulated to meet unusually rigid performance requirements in aircraft and missile applications.

In addition to the comprehensive industrial rubber technology we offer to help manufacturers solve rubber compounding problems. Colonial has large, modern and complete plant facilities to assure lower cost rubber molding and fabricating. We are *known* for our ability to meet manufacturer's "emergency" delivery requirements on priority projects.

Save time on your programs by sending prints and pertinent data on your *first* inquiry. We will promptly return an analysis and recommendations, together with illustrated information giving you complete details on our organization and its ability to serve you efficiently and economically.

1718-A

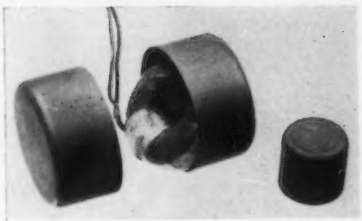
**COLONIAL RUBBER CO.**

706 Oakwood St. AXminster 6-9611

RAVENNA, OHIO

# electronic products

## MAGNETIC SHIELDS FOR TOROIDS



Lightweight Netic and Co-Netic foils provide effective shielding for toroidal transformers at minimum cost.

Foils lend themselves to simple encapsulation; shapes can be conforming, or like a pill-box in any size. The foils are non-shock sensitive, non-retentive and require no periodic annealing.

*Magnetic Shield Div.*
*Perfection Mica Co.*

Circle 107 on postcard for more data

## POTENTIOMETER FOR HI-TEMP USE

Leadscrew-actuated potentiometer has a power rating of 1.0 watt and a maximum

operating temperature of 175°C. Model 220 has a 100 per cent usable potentiometer range and is available in resistances from 100 to 20K ohms.

Measuring only 3/16 x

*continued on page 57*


**PLANT FACILITIES OPEN**

Diversified facilities available in mechanical, electro-mechanical, hydraulic, pneumatic fields. We will tool to meet your needs in fabrication and/or assembly. Have recently completed large government order, hence available facilities; skilled operators, supervisors.

*CONTRACT MFG. DIV.*
**CARSON MACHINE & SUPPLY CO.**
P. O. Box 4547 or Phone ME 4-0511
OKLAHOMA CITY, OKLAHOMA

Circle 26 on Inquiry Card

**American Beauty...an iron for every Soldering Job**

Whatever your soldering problem, American Beauty has the right iron for your particular job. The finest engineering, best materials and on-the-job experience since 1894 is yours with EVERY American Beauty. There is a right model, correct tip size (¼" to 1⅛") and proper watt-input (30 to 550 watts) to do any soldering job. Ask about which iron will do your job best. American Beauty electric soldering irons are the highest quality made.

ILLUSTRATED IS
CATALOG NO. 3125
¼" TIP SIZE, 60 WATTS

**TEMPERATURE REGULATING STANDS** Automatic devices for controlling tip-temperature while iron is at rest—prevent overheating of iron, eliminate frequent retinning of tip, while maintaining any desired temperature. Available with heavy-gauge perforated steel guard—protects user's hand.

YOU CAN'T BEAT A SOLDERED CONNECTION

203-B

WRITE FOR 28-PAGE ILLUSTRATED CATALOG CONTAINING FULL INFORMATION ON OUR COMPLETE LINE OF ELECTRIC SOLDERING IRONS—INCLUDING THEIR USE AND CARE.

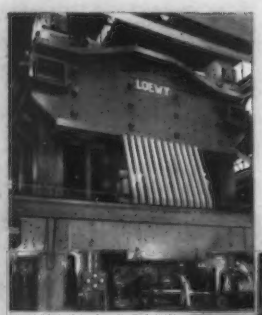
AMERICAN ELECTRICAL HEATER COMPANY
DETROIT 2, MICHIGAN

Circle 25 on Inquiry Card

# Hands of the Giants

## crack an egg or shape a missile

100,000,000 lbs. of pressure—so delicately controlled that it can be made to crack the shell of an egg. Use the fabulous forces of present day forging skills to crack the barriers of space—weight, strength, high temperatures. Forge the future, today.



EST. 1883

# WYMAN-GORDON

FORGING

ALUMINUM MAGNESIUM STEEL TITANIUM BERYLLIUM MOLYBDENUM COLUMBIUM
AND OTHER UNCOMMON MATERIALS

WORCESTER, MASSACHUSETTS

HARVEY, ILLINOIS
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GRAFTON, MASSACHUSETTS
FORT WORTH, TEXAS
FRANKLIN PARK, ILLINOIS
LOS ANGELES, CALIFORNIA



Circle 27 on Inquiry Card

Circle 28 on Inquiry Card →

# LINDE's NEW PLASMARC TORCH SERVICE

## *Brings Industry Production Parts From Refractory Metals*

No other method of fabricating refractory metals can match this. . . . The high melting points of tungsten, tantalum, and molybdenum are no longer a problem. For LINDE's new *PLASMARC* Torch, working in the temperature range between 15,000 and 30,000 degrees K., can coat parts or form shapes of virtually any size or complexity. It's an entirely new way to make such articles as rocket nozzles, crucibles, components for electronic and X-ray use, and parts for atomic energy equipment!

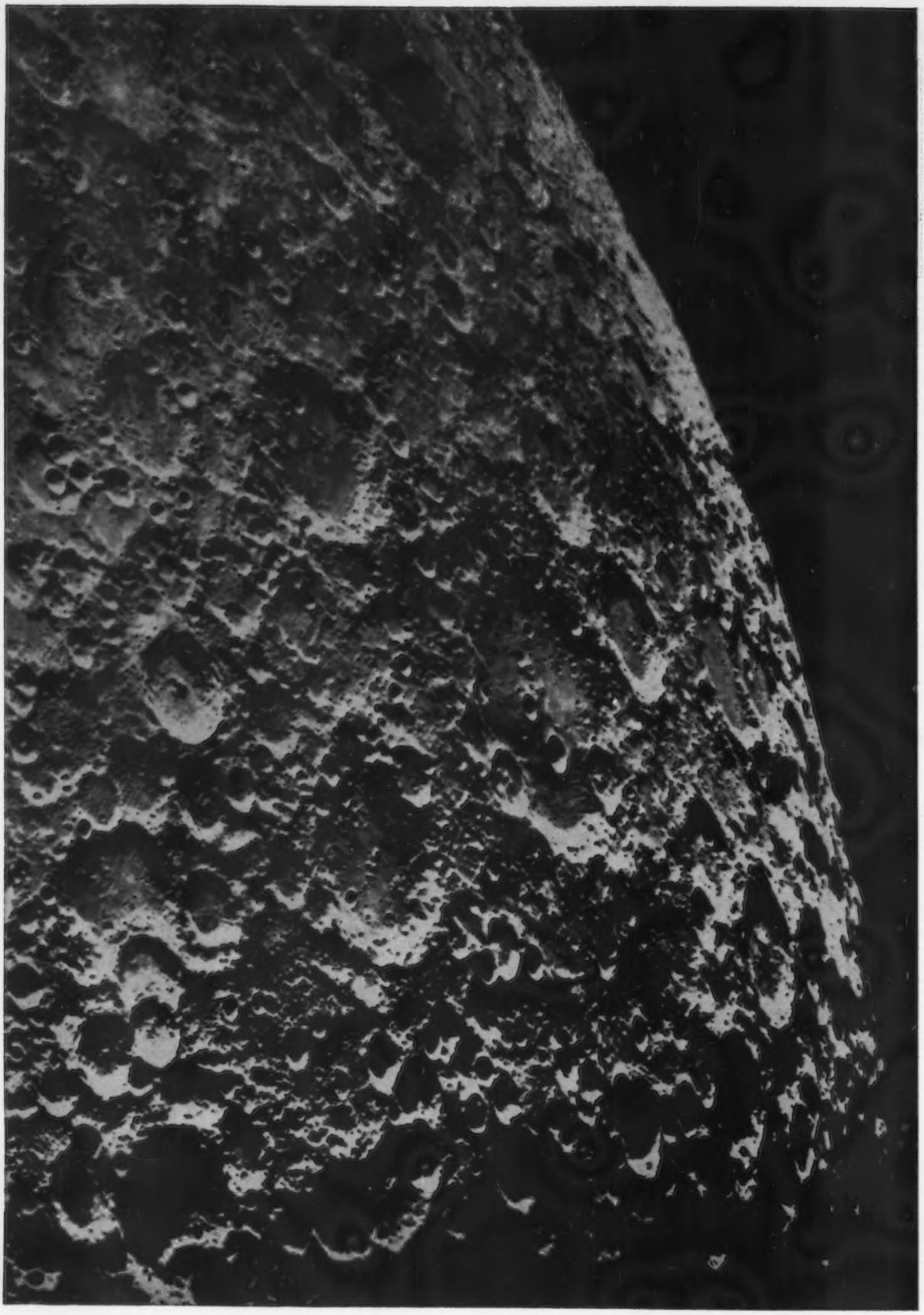
The quality of these pieces is uniformly high. Tolerances can be held to ±.002 in. or better. The metal loses none of its purity and superior density is achieved.

With the *PLASMARC* Torch, LINDE is equipped to supply you with parts made of, or coated with, refractory metals, or made of a variety of metals combined with non-metals or reinforced plastics. LINDE will also provide a wind-tunnel materials testing service based on this device. For information on this extension of LINDE's well-known Flame-Plating service, write Dept. AMM-08, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N.Y. In Canada: Linde Company, Division of Union Carbide Canada Limited.

The *PLASMARC* Torch employs a non-transferred electric arc to generate such high temperatures that powder or wire fed into the chamber is literally melted. Inert gases flowing continuously carry the metal particles in a plastic state and deposit them on the workpiece at near-sonic speeds. Jets of $CO_2$ cool the particles instantly to form heat- and erosion-resistant material. Coatings—even on graphite—have an excellent bond. Shapes are built up on machined mandrels, which are then etched away to leave parts such as those shown above.

Linde UNION CARBIDE

"Linde," "Union Carbide" and "Plasmarc" are trade marks of Union Carbide Corporation.



THE
MILITARY
REQUIREMENTS
FOR
MOON BASE

*This is the title of one of four major space proposals developed by Martin for the military and astroscientific branches of our Government. The importance of this proposal is two-fold: the inevitability of an actual moon base program by this country within the next 5 years, and; the fact that we could and can undertake such a project now— not in theory but in "hard" engineering design. For Martin's eight divisions add up to one of the top capabilities in the free world for man's first ventures in space-planetary exploration.*

MARTIN
BALTIMORE·DENVER·ORLANDO



5/16 x 1 in., units are designed for use with printed circuit boards and modular type assemblies. Mounting is easily done with 2-56 screws through stainless eyelets on ¾ in. centers.

*Bourns, Inc.*

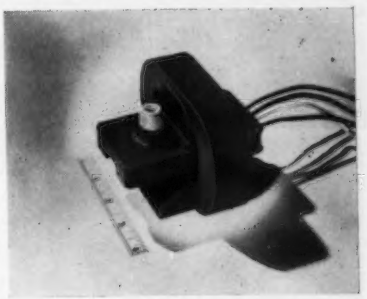
**Circle 108 on postcard for more data**

## VOLTAGE-TUNABLE MAGNETRON

A voltage-tunable magnetron (VTM) previously available only in sample quantities is now in full production.

Redesign has made possible the die-casting of certain metal parts into integral assemblies, thus reducing the number of sub-assemblies and lowering chances of unit failures from misalignment of parts.

The unit is voltage-tunable over part or all of a frequency spectrum from 2200 to 3850 megacycles, with a minimum CW power output of 2 watts across the entire frequency range.



Weight is only 3.1 lb. Dimensions are approximately 4 x 4 x 3¼ in.

*General Electric Co.*
*Power Tube Dept.*

**Circle 109 on postcard for more data**

## DAMPING GENERATOR

Weighing only 1.3 oz, a new size 6 Damping Generator will deliver a stall torque of 0.11 oz in./min. Acceleration from stall is 23,600 radians/sec/sec,

# electronic products

*continued from page 57*

A SIZE 6 DAMPING MOTOR GENERATOR

and moment of inertia is 0.33 g-cm².

The generator requires an input of 26 v at 400 cps. The maximum null is 12mv, and the minimum signal to noise ratio does not exceed 8.

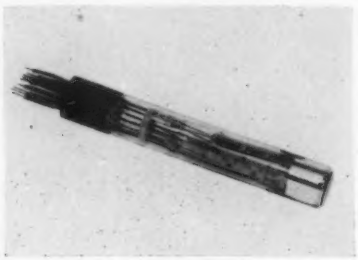
*Daystrom Transicoil*

**Circle 110 on postcard for more data**

## PHOTOTUBES SAVE SPACE

Two ¾-in. diam multiplier phototubes have been made available for use where size and weight are important considerations. Both tubes have 10 dynode stages and feature potted bases for moisture and shock resistance, socket elimination, and noise-free connections.

Tubes are identical in design and performance except in



secondary emission characteristics. Type 6362 with silver magnesium dynodes features maximum stability at high voltages, while type 6935 with cesium antimony dynodes features high gain at low opening voltages.

*Electronic Tube Sales Dept.*
*Allen B. DuMont Labs. Inc.*

**Circle 111 on postcard for more data**

## VOLTAGE STANDARDS

A new line of voltage standards has been introduced by Consolidated Controls Corp.

Manufacturer claims that the constant-voltage sources "combine laboratory precision with field ruggedness." Output stability for most types is better than 0.1 per cent for input variations of 20 per cent. All types

pass the shock and vibration requirements of MIL-E-5272A.

Units are available for DC inputs in the 18-to-30 v. range, and for 60 and 400-cycle AC from 90 to 130 v.

*Consolidated Controls Corp.*

**Circle 112 on postcard for more data**

Valve casting and its MONO-SHELL

Misco's MONO-SHELL process permits manufacture of many new components once avoided by conventional investment casting systems. Castings by MONO-SHELL weighing 25 lbs., 12" dia. x 6" high, poured in air or vacuum by the DOUBLE-V system are commonplace today.

Surface qualities in the as-cast condition average 70-90 R.M.S.

MONO-SHELL permits wide selection of stainless steels and high temperature alloys with improved metallurgical qualities and properties.

| Stainless Steels | | Hi Temp Alloys | | Vacuum Alloys | |
|---|---|---|---|---|---|
| 310 | 304 | AMS 5382 | AM 355 | A-286 | Udimet 700 |
| 410 | 316 | AMS 5385 | WI-52 | 713 | GMR 235 |
| 347 | 17-4 PH | AMS 5388 | Vascojet 1000 | Waspaloy | Rene' 41 |
| 431 | | | | Udimet 500 | |

*Write us for specific data on alloys produced by MONO-SHELL; or better still, submit your drawings to our Engineering Staff for a value analysis.*

Misco Precision Casting Company

Plants in WHITEHALL, MICHIGAN MUSKEGON, MICHIGAN

MISCO

Address inquiries to 124 Gibbs St. WHITEHALL, MICHIGAN Whitehall 2-1515

Sales Offices in Principal Cities

PRODUCERS OF AIRCRAFT AND INDUSTRIAL INVESTMENT CASTINGS

FIRST RULE
FOR
DELEGATING
GROUND
SUPPORT
EQUIPMENT
RESPONSIBILITY:

# FIND AN AUTHORITY

Through 70 years of war and peace, St. Louis Car has developed, tested and built transport and handling equipment . . . railroad stock . . . amphibious vehicles . . . aircraft . . . special-purpose carriers and mounts.

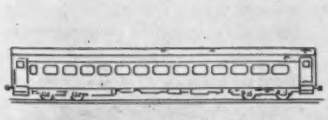
Use this experience when you need transport and handling equipment, engineered from the systems approach to meet the specific operational objectives of your weapon.

Before you assign any transport and handling equipment work—from R&D to production—evaluate St. Louis Car. We welcome the chance to submit proposals.

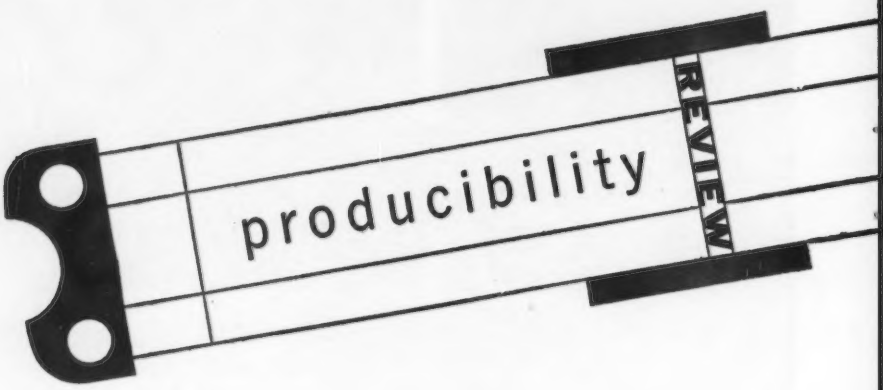
## ST. LOUIS CAR COMPANY

St. Louis 15, Mo.

**Write on your letterhead for Information Kit SA-11.**



# AIRCRAFT & MISSILES MANUFACTURING DIGEST OF RECENTLY PUBLISHED TECHNICAL MATERIAL




## DESIGN

THRUST CONTROL OF SOLID PROPELLANT ROCKETS. H. W. Ritchey. *Western Av.* (March, 1959) 2 pp. Brief presentation of problems involved and some current methods adopted to effect thrust control.

A SURVEY OF HYPERSONIC-RAMJET CONCEPTS. R. J. Weber. *ARS paper #875-59* (June 11, 1959) 14 pp. Brief discussion of the major problem areas in hypersonic ramjet engine development. Survey covers some of the relatively unconventional concepts such as supersonic combustors, under-wing burning, atmospheric-recombination, nuclear power, variable geometry, and fuel-rich operation.

AN APPROACH TO THE PRACTICAL DESIGN OF RELIABLE, LIGHT WEIGHT, HIGH STRENGTH PRESSURE VESSELS. E. B. Kinnaman, R. E. Jacobsen, and C. F. Tiffany. *IAS paper #59-109.* (June 19, 1959) 24 pp. Discussion on Boeing's experience gained from the development of IM-99 pilotless interceptor. Topics covered include brittle failure, material toughness, discontinuity stresses, factors of safety, proof test, weld efficiency factors, feasibility, quality control and reliability.

THERMAL SHOCK RESISTANCE — A DESIGN PARAMETER FOR CERAMIC RADOME WALLS. E. J. Luoma and E. B. Shand. *Aero/Space Eng.* (June, 1959) 5 pp. Experimental data on several candidate radome ceramics are reported for thermal stresses both perpendicular and parallel to the radome wall. Data are given for Pyroceram Brand glass ceramic, high purity alumina, and fused silica.

BOOSTER DESIGN FOR A 20,000-POUND SATELLITE. S. B. Kramer and R. A. Byers. *Space/Aero.* (June, 1959) 4 pp. Detailed analysis of requirements for a multi-manned satellite, based on the current state of the art.

THUNDERCHIEF—"THE MOST POWERFUL ONE-MAN AIRPLANE IN THE WORLD." *Flight* (June 12, 1959) 4 pp. Development and design features are discussed. A general cutaway sketch of airplane is included.

## PRODUCTION

AUTOMATIC SPOTWELDING REPLACES RIVETING. G. H. DeGroat. *Amer. Mach.* (June 15, 1959) 2 pp. Tape control and television are used in building aluminum fuselage sections for Boeing's KC-135 tanker transport.

FORGER SIZES JET ENGINE PARTS WITH FAST, SIMPLE CYCLE. *Iron Age.* (June 18, 1959) 1 pp. Forming of the outer shroud of jet aluminum compressor inlet vanes is simplified by a new forger and upsetter imported from Germany.

DE HAVILLAND COMET—MAINPLANE ASSEMBLY: STUB-WING TO CENTRE-SECTION POINT. W. E. Goff. *Aeft. Prod.* (April, 1959) 12 pp. Materials, methods, production equipment and special jigs are discussed.

EXPLOSIVE FORMING . . . HOW IT WORKS, WHAT IT DOES. R. A. Cooley, G. H. DeGroat, J. Savitt, and T. A. Dickenson, *Amer. Mach.* (June 15, 1959) 12 pp. A special report reviews the state of the art of this process.

## MATERIALS AND PROCESSES

COMPLEX TUNGSTEN PARTS — NEW FORMING METHODS MAKE THEM PRACTICAL. R. W. Yancey. *Materials in Des. Eng.* (June, 1959) 3 pp. Discussion of tungsten properties, and how they affect fabrication. Some typical parts are shown made by forming, spinning, forging, extrusion, and deep drawing.

SELECTION OF MATERIALS FOR HYPERSONIC LEADING EDGE APPLICATIONS. F. M. Anthony and H. A. Pearl. *IAS paper #59-111* (June 19, 1959) 44 pp. Design and environmental conditions are reviewed, analytical methods used for calculation of temperatures and thermal stresses are summarized, and typical results relating material and geometric factors are presented. Ten

*continued on page 62*

# This is all the room you need to weld with LINDE's "MIGHTY MIDGET"

## ... New Heliarc HW-20 Torch

### HIGH CURRENT CAPACITY

Operates at 200 amperes *continuous* duty, AC or DC. Molded, totally closed water-cooling system eliminates any chance of leaks at torch head.

### MINIATURE SIZE

9/16- by 2-5/16-in. torch head permits welding in hard-to-reach areas as small as 3 in. in diameter. Total torch length is under 7 inches.

### 3.3-OZ. FEATHERWEIGHT

Selected materials, such as glass fiber reinforced phenolic plastic, save weight without sacrificing strength. Torch (with short cap) weighs only 3.3 ounces.

### HANDLES LIKE A PENCIL

Exceptional balance, light weight, small size, and super-flexible service lines make the HW-20 torch as easy to handle as a pencil.

For further information, call your local LINDE Office or LINDE Distributor . . . or write: Dept. AMM-08, LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, New York.

### SPECIFICATIONS

**Capacity—**
200 amp. AC or DC, continuous duty cycle;
225 amp. AC or DC, reduced duty cycle

**Weight—**
with short cap: 3.3 oz.*
with medium cap: 3.5 oz.
with long cap: 3.6 oz.

**Length overall—6⅞ in.**

**Length of Torch Head—**
with short cap: 2-19/64 in.*
with medium cap: 3-9/32 in.
with long cap: 7-5/16 in.

**Maximum Handle Diameter—¾ in.**

**Maximum Head Diameter—9/16 in.**

**Service Lines—12½ or 25 ft.**

*Torch is supplied with medium cap for 3-in. electrodes. Short cap for 2-in. electrodes and long cap for 7-in. electrodes are available as accessories.

Linde UNION CARBIDE

The terms "Heliarc," "Linde," and "Union Carbide" are registered trade marks of Union Carbide Corporation.

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*Now! A higher reliability factor in printed circuits*

# ALTORI

## a new and distinctively different finish on TAYLOR copper-clad laminates that accepts all acid resists uniformly

Something new and distinctively different has been added to TAYLOR copper-clad laminates — a finish that accepts all types of acid resists uniformly. High fidelity in printed circuit reproduction is assured. Circuits can be of consistently higher quality and reliability, no matter how critical the design. For complete details about TAYLOR copper-clad laminates and samples, write TAYLOR FIBRE CO., Norristown 50, Pa.

**Taylor**

*LAMINATED PLASTICS VULCANIZED FIBRE*

refractory materials are compared and region of applicability is indicated for each.

## BOOKS RECEIVED

GAS TURBINES FOR AIRCRAFT. A. W. Judge. *Macmillan*, 1959. 439 pp. $12.00. An overall treatment of gas turbines for engineers, technicians and students, extending from the historical background to the complex powerplants of today. Representative types of turbines and their sub-systems are illustrated and discussed, as well as, such related subjects as maintenance, exhaust silencing thrust reversal, high-temperature materials etc. Over 150 bibliographic references are provided for the reader who would like to delve beyond this "intermediate" treatment of the subject matter. A 16-page closing chapter is devoted to the elementary thermodynamics of gas turbines.

AIRCRAFT ELECTRICITY FOR THE MECHANIC. C. E. Chapel. *Aero Publishers*, 1959, second edition, 477 pp. $5.00. Electrical fundamentals and applications presented in a readily-understandable terms, for laymen and technicians. The comprehensive practical coverage of this book makes it suitable for home-study, for use by secondary and vocational schools, also for applicants for Federal Aeronautics Administration examinations to obtain licenses as Aircraft Mechanics and Aircraft Engine Mechanics.

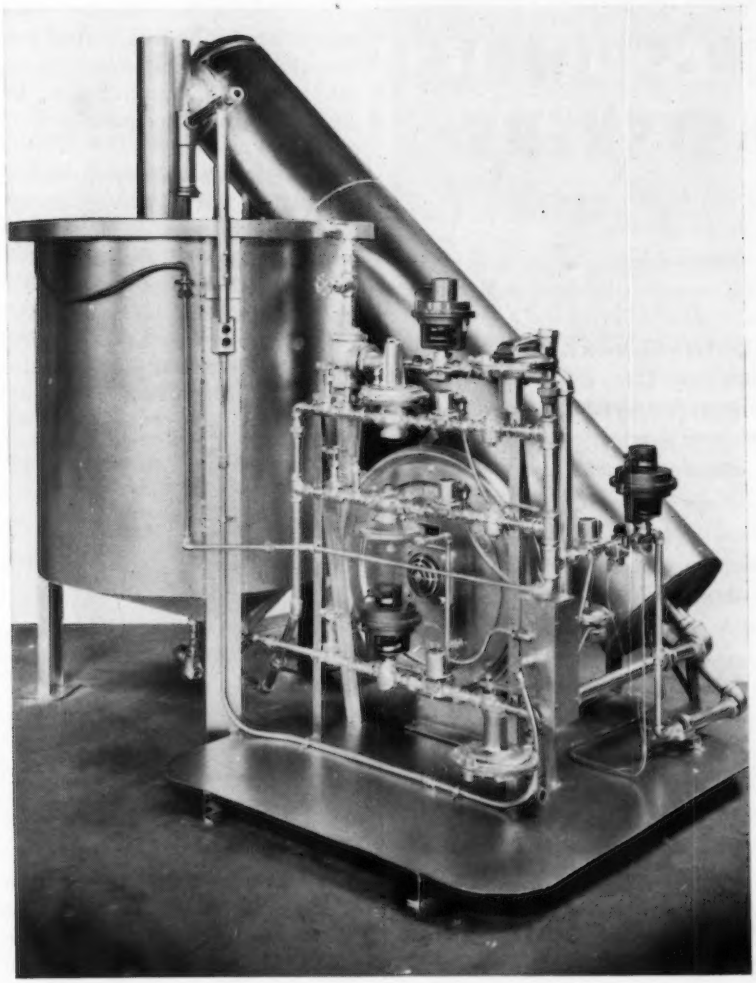
## REVIEWED IN THIS ISSUE

### Periodicals and Papers

**Acft. Prod.** Aircraft Production (British)
**Aero/Space Eng.** Aero/Space Engineering
**Amer. Mach.** American Machinist
**ARS Paper** American Rocket Society paper
**Flight** Flight (British)
**IAS Paper** Institute of Aeronautical Sciences paper
**Iron Age** The Iron Age
**Mach.** Machinery
**Materials in Des. Eng.** Materials in Design Engineering
**Space/Aero.** Space Aeronautics
**Western Av.** Western Aviation

### BOOKS RECEIVED

**Aircraft Electricity For The Mechanic.** Aero Publishers
**Gas Turbines For Aircraft.** Macmillan



## GAS FIRED 2000-4000°F RESEARCH FURNACE

Gas-fired furnace features specially-designed burners providing almost perfect combustion. Burners require no water cooling and use a standard 16 oz. blower.

Operating temperatures range from 2000°F to 4300°F. The furnace is especially useful in testing components such as thermocouples which might be affected by stray currents if used in conjunction with electric furnaces.

The illustrated furnace has a heating chamber 6 in. in diameter and 6 in. high. Size can be varied to meet specific requirements. Refractories are of zirconium oxide, a relatively new refractory material made especially for high temperature applications.

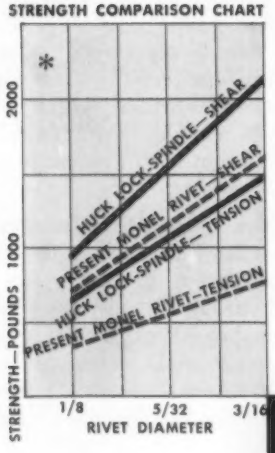
Furnace operation is started with a pre-heat burner which raises cavity temperature slowly to 1000°F. to avoid thermal shock to refractories. The main burner operating on a lean air-gas mixture raises the temperature to 1800°F. Above that temperature the burner, using a

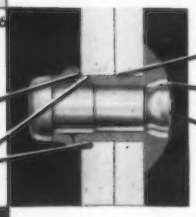
# HUCK MONEL

## LOCK-SPINDLE FASTENERS

- Greatly increased shear and tensile strength*.
- Requires no pin trimming.
- Positive mechanical lock.
- 1/16" grip increments (Interchangeable with MS rivets).
- 1/8, 5/32, 3/16 diameters. Protruding or countersunk head.
- Excellent strength at elevated temperatures.
- Compatible with high temperature materials.
- Strongly corrosion resistant.
- Broad blind side bearing, ideal for thin stock.
- Visual, drive side inspection.
- Fast, uniform installation (unskilled).
- Installs with standard Huck tools.
- A thoroughly proved fastener design.

STRENGTH COMPARISON CHART



Broad blind side bearing.

Extra shear strength.

Excellent pull-together and clinch.

Positive mechanical lock.

No pin trim necessary.

Representatives in all principal cities.

**HUCK** *MANUFACTURING COMPANY*

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normal fuel mixture with pre-heated air from the cavity, raises the temperature at the rate of 700°F. per hour. No oxygen enrichment is needed for temperatures up to 3800°F. At 3800°F, the fuel mixture is enriched by oxygen to enable the temperature to rise to 4300°F. Gas, pre-heated air, and oxygen are all automatically proportioned.

*Hirt Combustion Engineers*

Circle 113 on postcard for more data

## NOISE PROTECTION

Muff-type protector with microphone unit is designed for the industrial employee whose job involves communication in the presence of extremely loud operating noises.

The protector-earphone of this improved Straightaway model attenuates an extra 10 decibels of sound for better reception and for maximum protection against hearing injury.

Transmissions are made through a carbon microphone, built into a noise reduction

shield connected to the headband of the protector.

The mike shield is equipped with a push-to-talk button

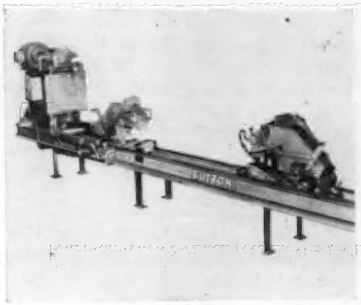
which eliminates feedback. The button is substituted for a toggle switch if preferred.

*David Clark Co.*

Circle 114 on postcard for more data

## STRETCH-STRAIGHTENS AT HIGH SPEED

This 20-ton hydraulic stretcher stretch-straightens extruded sections of aluminum and other modern metals at high production speeds.



Vertical jaw design provides horizontal pass line through head and tail stock for ease of material handling. Extrusions up to 100 ft. long can be stretch-straightened at high rates of production up to a 20 ton pull. At less than 6 tons pressure, higher speeds up to 400 in. per minute can be realized. Length of stroke of the head stock is 48 in.

*Sutton Engineering Co.*

Circle 115 on postcard for more data

## INTERNAL MICROMETER

The "Multi-Mike" internal micrometer measures cylinder groove and land widths; O-ring widths; groove and keyway locations. Measurements accurate to .0005 in. are possible from .050 in. to 1.050 in. for groove widths; from zero to 1.000 in. for lands and distances between grooves. Current model will locate from an external reference to its probe depth of 5¾ in.

*Navan Products Inc.*

Circle 116 on postcard for more data


HUCK

VERSATILE

"200"

UNIVERSAL PNEU-HYDRA BLIND RIVET INSTALLATION TOOL

*for installing*

**HUCK CKL; HUCK MONEL LOCK-SPINDLE; MIL-R-7885-AD & B AND MIL-R-8814, BOTH K AND W STEMS; AS WELL AS BLIND LOCK-BOLTS, HUCKBOLTS* OS AND DAISY RIVETS.**

*Trademark Huck Manufacturing Co.

The Huck "200" is a sturdy, light weight (10 pounds) tool which will install up to thirty fasteners per minute in unskilled hands. Its construction is simple and husky, developing 3000 pounds pull at 90 p.s.i. air line pressure. Because it has so few moving parts, wear and maintenance service is minimized.

Single action adjustment to various fastener sizes is automatic—quick change, preset cartridges adjust for double action use with no further adjustments necessary.

The "200" uses standard nose assemblies.

(Also available in kit form for maintenance service).

HUCK MANUFACTURING COMPANY

Representatives in all principal cities.

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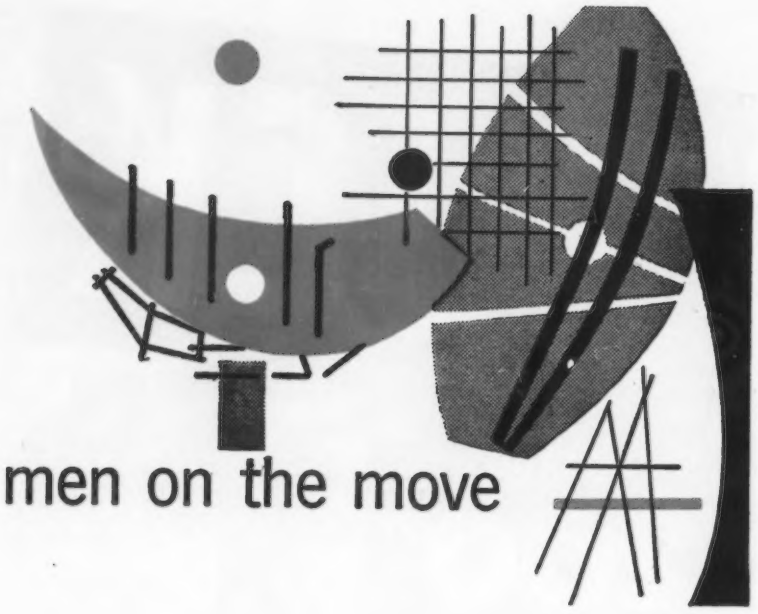


# men on the move

George E. Smith
Martin

J. Donald Rauth
Martin

GEORGE E. SMITH, named general manager of the Martin Company's Cocoa Div., Cape Canaveral, Fla. J. DONALD RAUTH, general manager of Martin's Nuclear Div., was elected a vice president of the company. ADOLPH VLCEK JR., appointed director of manufacturing at the Baltimore Div.

Vincent E. Ryb
A. C. Spark Plug

Thomas P. Peppler
Vertol

VINCENT E. RYB, appointed manager of the Titan intercontinental ballistic missile guidance program at AC Spark Plug, Div. of General Motors. DONALD F. AYRES, named manager of the firm's Thor and Mace missile guidance programs.

THOMAS P. PEPPLER, appointed project manager and HARVEY H. KLEIN, named project engineer for the YHC-1B helicopter program at Vertol Aircraft Corp. KENNETH GILLMORE, appointed chief of preliminary design, the position formerly held by Peppler.

WILBERT H. YAHN, elected a vice president of North American Aviation, Inc. and appointed manager of the company's Columbus, O. Div.

Richard S. Stevens
U.S. Chemical
Milling Corp.

Morris Lebovits
Solar

RICHARD S. STEVENS, named manager of the new department of market development for the U. S. Chemical Milling Corp. LELAND E. BRUCE has been advanced to assistant production manager of the Chemical Milling Div.

MORRIS LEBOVITS, named section chief-aerodynamics, Solar Aircraft Co.

DR. EARL L. STEELE, appointed assistant manager of the development laboratory for the semiconductor division of Hughes Aircraft Co.'s Products Group.

OSCAR H. BAUSCHINGER, appointed Jupiter Project Manager for Ford Instrument Co., Div. of Sperry Rand Corp.

LT. GEN. CLARENCE S. IRVINE USAF, Ret. has joined Avco Corp. as vice president and director of planning.

L. B. STEARNS, promoted to project manager, U. S. Chemical Milling Corp. DON C. ATKINS, named director of the new Technical Dept.

DR. WILLIAM C. KNOPF, named technical director of the USI Technical Center, Pompano Beach, Fla., research and development division of U. S. Industries Inc.

JOHN G. ZIEMANN, named assistant chief metallurgist, Metals Div., Kelsey-Hayes Co.

JOHN K. ELDER, appointed vice president, Applied Research & Testing Laboratories.

ALFRED J. MOSES was named manager of radioactive laboratory operations of Isotopes Specialties Div.; JOHN D. VADEN has joined Isotopes Specialties as Health Physics officer; and NYLE SCHAFHAUSER will run Isotopes Specialties' experimental shop; at Nuclear Corp. of America.

JOHN S. HALL, appointed manager of manufacturing, Gabriel Electronics Div., The Gabriel Co.

MAJOR GEN. E. BLAIR GARLAND USAF ret., has joined Philco Corp.'s Government & Industrial Div. as manager of a new military communications group handling the $19-million AIRCOM modernization contract. HENRY E. HOCKEIMER, named AIRCOM project director.

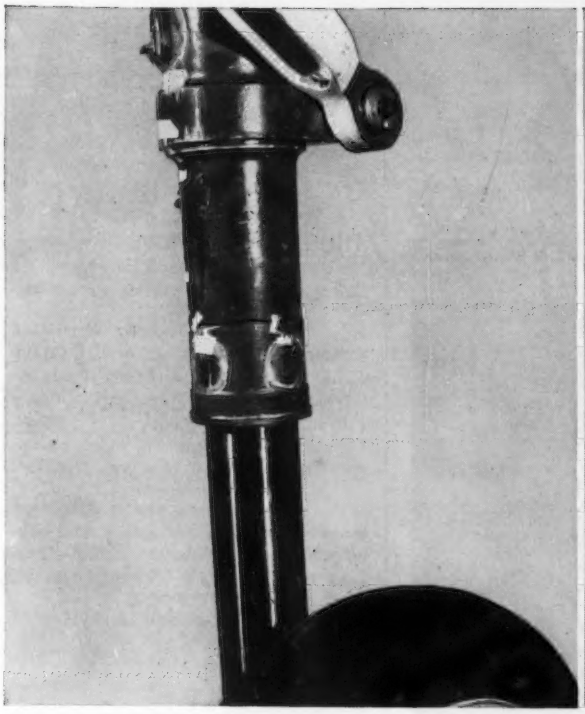
DONALD B. DOOLITTLE will direct the new Advanced Technical Planning Div. of All American Engineering Co.

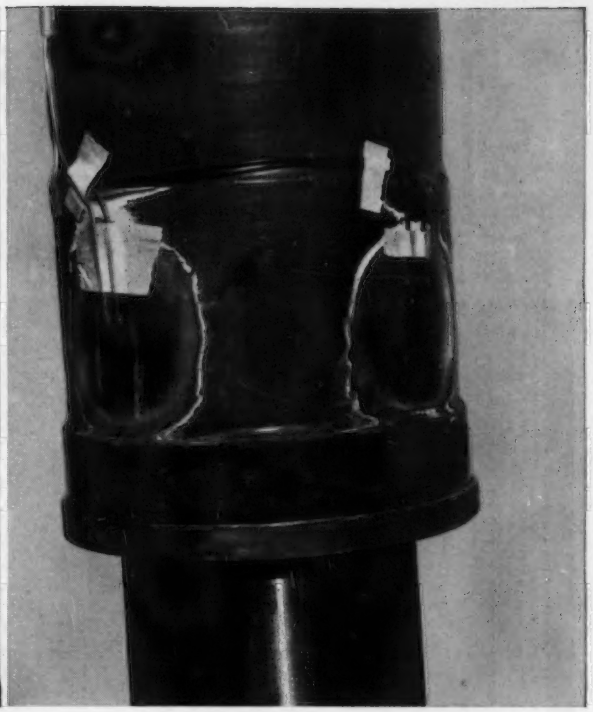
FRANK L. BAILEY, president and sales manager of the newly-formed Chemical Milling International Corp.

VERNON RAWLINGS, general manager of new Activation Div. at General Electric. Division will help USAF's Ballistic Missile Div. activate operational bases using Titan.

Y. C. LEE, appointed manager of Aerojet General's new Space Technology Div.

*continued on page 68*





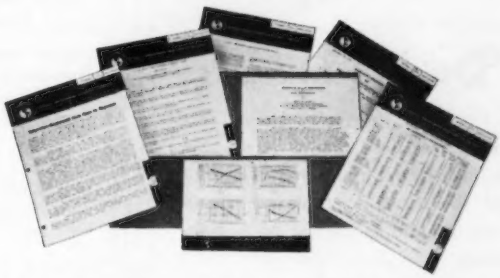
# MetalFilm Strain Gages . . . used by Douglas Aircraft

**these superior gages can be easily applied by your technicians, too**

The landing gear being tested here belongs to a Douglas A4D Skyhawk jet attack bomber. Technicians at Douglas Aircraft's El Segundo Division use MetalFilm strain gages for testing purposes since they are quick and easy to apply, especially when contact cement is used, yet they yield consistent, accurate results. MetalFilm gages in sizes ranging down to 1/16" are used at Douglas.

At Tatnall, improvements over conventional strain gages have been achieved through the use of a unique combination of ultra-thin, precisely controlled alloy foil with plastic and strippable backings. Yet, these gages can be applied as easily . . . if not more easily . . . than conventional gages.

MetalFilm Strain Gages are flexible, temperature compensated, and stabilized. *Many can be applied in less than 5 minutes.* A wide variety of sizes covering high and low temperature ranges is available.

To give you better service, MetalFilm Strain gages are supplied direct from the factory . . . and are backed with readily available technical assistance. Discounts are given on quantity purchases. For literature and information

about MetalFilm Strain Gages, their specifications, application and prices, contact our Department AM-8.

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## Double-Value

## "Double-Seal"™ Ball Valves

3" Jamesbury High Pressure Valve in use at Goodyear Tire & Rubber Company, Akron, Ohio, on 3,000 P.S.I. Water Service at Ambient Temperature.

**Double EFFICIENCY**

In the high pressure water service installation shown here, and wherever the Jamesbury "Double-Seal" principle is employed, there is double the efficiency of performance.

**HIGH PRESSURE**
**Style "H" Valve**
*(3,000-4,500 pressure range)*

In ¼" thru 2" pipe and tubing sizes* for:

High Pressure service
High Vacuum service
Handling of hazardous fluids
Cryogenic operations

*Larger sizes on application

*Distributors In Principal Cities Get The Complete Facts On The Jamesbury "Ball Valve" Principle.*

584-B

Name_____ Title_____

Company_____

Address_____

City_____ State_____

☐ Jamesbury Literature
☐ Distributor Service

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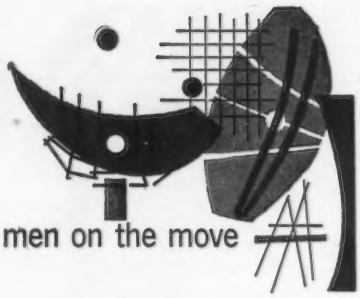


**PAUL J. PAPANEK**, appointed director of marketing and **RICHARD A. DAVIS**, appointed director of administration; in The Marquardt Corp.'s Power Systems Group. **L. E. DUNN**, formerly chief engineer, has been appointed director of the Test Division.

**JACK R. WALCHLI**, appointed manager of the Licensing and Research Department of Navan Products Inc.

**JAMES W. ASHBY**, appointed general manager of the Janitrol Aircraft Div., Surface Combustion Corp. **JOSEPH F. HILL**, appointed manager of engineering.

Jack R. Walchli
Navan Products Inc.

James W. Ashby
Janitrol

**RICHARD B. LAVER**, appointed comptroller of the Bendix-Pacific div. of Bendix Aviation Corp.

**RICHARD W. COOK**, appointed deputy group executive and divisional vice president, Government Products Group, American Machine & Foundry Co.

**DR. HERBERT TROTTER, JR.**, elected a Senior Vice President of Sylvania Electric Products Inc.

Richard W. Cook
American Machine & Foundry Co.

Dr. Herbert Trotter Jr.
Sylvania Electric Products

# worth asking for:

technical literature listed here is available without charge from the various manufacturers

**Pyroceram**

Third in a series of progress reports on Pyroceram materials.

*Corning Glass Works*

**Circle 117 on postcard for more data**

**Titanium**

24-page fact file on titanium and titanium alloys.

*Mallory-Sharon Metals Corp.*

**Circle 118 on postcard for more data**

**Environmental Equipment**

Brochure describes and illustrates types.

*Wyle Laboratories*

**Circle 119 on postcard for more data**

**Facilities**

Brochure shows makeup of divisions, describes equipment.

*Sargent Engineering Corp.*

**Circle 120 on postcard for more data**

**Test Instruments**

Catalog lists line of instruments automatically measuring sound, vibration, strain.

*B & K Instruments Inc.*

**Circle 121 on postcard for more data**

**Tape Recorder**

Four-page bulletin describes Type 5-781 Magnetic Tape Continuous-Loop Recorder/Reproduceer.

*Consolidated Electrodynamics Corp.*

**Circle 122 on postcard for more data**

**Information Technology**

Brochure "This Is Itek" describes facilities, activities of advanced communications firm.

*Itek Corp.*

**Circle 123 on postcard for more data**

**Control Boards**

28-page color booklet, "To Speed Up Operations," tells how Produc-Trol—the peg-and-tape control system—speeds design and production of Jupiter and Redstone IRBM's.

*Wassell Organization Inc.*

**Circle 124 on postcard for more data**

**Electric Motors**

12-page catalog on basic line of fractional hp electric motors, blowers, and special products.

*Redmond Co*

**Circle 125 on postcard for more data**

**Acceleration Testing**

Features, specs, of line of centrifuge acceleration test machines.

*The Rucker Co.*

**Circle 126 on postcard for more data**

**Precision Manufacturing**

Brochure shows precision manufacturing process: engineering, facilities, laboratories.

*Indiana Gear Works Inc.*

**Circle 127 on postcard for more data**

**Atmosphere Heat Treating**

Applications covered in Newsletter.

*Ferrotherm Co.*

**Circle 128 on postcard for more data**

**Tape Material**

Booklet on reliability of "Mylar" and acetate film for magnetic tape.

*E. I. du Pont de Nemours*

**Circle 129 on postcard for more data**

**Stainless Steel**

77-page book on Cold Drawn Stainless Steel Wire.

*Uddeholm Co. of America*

**Circle 130 on postcard for more data**

**Transducers**

Brochure 1000 SD 6 describes three basic force balance pressure transducers: Static Pressure, Pressure Ratio, and Pressure Difference; the basic units employed in intricate air data computers.

*M. Ten Bosch Inc.*

**Circle 131 on postcard for more data**

**Charts**

Two charts: codes for telephone direct distance dialing; time zone map for U. S. A.

*Ohio Seamless Tube Div.*
*Copperweld Steel Co.*

**Circle 132 on postcard for more data**

**Low-Cost Tooling**

66-page blue book contains case histories on industry's approach to low-cost tooling with standard industrial power tools.

*Delta Power Tool Div.*
*Rockwell Manufacturing Co.*

**Circle 133 on postcard for more data**

**Voltage Regulators**

60-page illustrated booklet describes redesign of dry type and liquid filled Inductrol voltage regulators 60 and 400 cycles.

*General Electric Co.*

**Circle 134 on postcard for more data**

**Magnetic Tape**

Catalog DC-3171 on Honeywell multichannel magnetic tape system for laboratories, test cells, telemetering recording.

*Minneapolis-Honeywell*

**Circle 135 on postcard for more data**

**Sylvania**

Revised edition brochure, "Sylvania Electronic Systems for National Defense."

*Sylvania Electronic Systems*

**Circle 136 on postcard for more data**

**Spring Steel**

Physical data of cold-rolled high-carbon flat spring steels, plus firm's manufacturing methods.

*Athenia Steel Div.*
*National-Standard Co.*

**Circle 137 on postcard for more data**

**Stainless Steel Strip**

Eight-page brochure on new plant and facilities for cold finishing stainless steel strip.

*Universal-Cyclops Steel Corp.*

**Circle 138 on postcard for more data**

*continued on next page*

## worth asking for:

technical literature listed here is available without charge from the various manufacturers

**SAGE**

Summary of SAGE system.

*Burns & Roe Inc.*

**Circle 139 on postcard for more data**

**Titanium Fasteners**

A cataloging of firm's titanium fasteners and special products, plus a review of special facilities.

*Standard Pressed Steel Co.*

**Circle 140 on postcard for more data**

**Seals Manual**

20-page design catalog on the Bellofram seal with a detailed analysis on four basic classes of seals.

*Bellofram Corp.*

**Circle 141 on postcard for more data**

**Deep-Groove Bearings**

Bulletin 110 on line of deep-groove ball bearings.

*Hoover Ball and Bearing Co.*

**Circle 142 on postcard for more data**

ALL THE PRODUCTION YOU'LL EVER WANT — ALL THE PRECISION YOU'LL EVER NEED
BUT MY WORK INCLUDES THE MANUFACTURE OF—
I KNOW! AND YOU CANNOT POSSIBLY BUY A BETTER MACHINE FOR THE JOB THAN—
THE HAMILTON No. 1-B PRECISION SMALL GEAR HOBBING MACHINE
INVESTIGATE IT! YOU'LL SEE!
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WORMS
SPECIAL TOOTH FORMS
GEAR SECTORS
PINIONS
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and BEVEL GEARS (up to 3" O.D.)
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PRECISION SMALL-GEAR HOBBING MACHINE
THESE ARE REPRESENTATIVE USERS OF HAMILTON GEAR HOBBING EQUIPMENT
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THE HAMILTON TOOL COMPANY • 882 SOUTH NINTH STREET • HAMILTON, OHIO


**Electrohydraulic Servoactuator**

Catalog 170 on line of electrohydraulic servoactuators.

*MOOG Servocontrols*

**Circle 143 on postcard for more data**

**Small Parts**

Brochure describes production of small high precision machine parts.

*La Vezzi Machine Works*

**Circle 144 on postcard for more data**

**Connectors**

Spacecraft and missiles pictured in 12-page brochure on connectors.

*Burndy Corp.*

**Circle 145 on postcard for more data**

**Finishing**

30-page catalog on precision mechanical finishing and automatic finishing processes.

*Roto-Finish Co.*

**Circle 146 on postcard for more data**

**Fiberglass Structure**

Illustrated brochure describes wide variety of filament-wound fiberglass structures.

*Aviation Div.*
*Walter Kidde & Co.*

**Circle 147 on postcard for more data**

**Products List**

Description of some 60 chemicals, metals, and minerals for chemistry, ceramics, electronics.

*Foote Mineral Co.*

**Circle 148 on postcard for more data**

**Lockheed**

Brochure on Lockheed Aircraft Service.

*Lockheed Aircraft Service*

**Circle 149 on postcard for more data**

**Check Valves**

Design features of small cartridge-type check valve.

*Kepner Products Co.*

**Circle 150 on postcard for more data**

**Bearing Fits**

Manual contains instructions to prevent premature bearing failures and off-schedule removals; procedures for accurate bearing fits.

*Bearing Inspection Inc.*

**Circle 151 on postcard for more data**

**Hydraulic Tracer Controls**

Brochure contains outline of firm's tracer control methods.

*Micro-hydro Duplicator Div.*
*James Engineering & Machinery Co.*

**Circle 152 on postcard for more data**

**Nuts and Fasteners**

Line of clinch, pilot and weld nuts in standard and special types is fully described with specs and applications.

*The McLaughlin Co.*

**Circle 153 on postcard for more data**

**Microwawe Measurements**

320-page book on microwave measurements provides comprehensive theory, plus practical help on applications. Available to engineers in microwave work requesting on company letterhead.

*DeMornay-Bonardi*

**Circle 154 on postcard for more data**

**Nameplate Designing**

Twenty-page booklet is guide to the engineer designing or specifying nameplates for new products in the development stage.

*H. G. Dietz Products Co.*

**Circle 155 on postcard for more data**

**Oxygen Cleanliness**

Bulletin on Black-Light Lamps used in inspection procedures for oxygen service cleanliness.

*Black Light Eastern Corp.*

**Circle 156 on postcard for more data**

**Resistance Elements**

2-color, 6-page catalogue provides complete data on a standard line of RdF resistance thermometer elements.

*RdF Stikon*

**Circle 157 on postcard for more data**

**Water Treating**

24-page booklet presents latest developments in water treating equipment.

*Elgin Softener Corp.*

**Circle 158 on postcard for more data**

**Welding Stainless**

Folder includes information on the welding characteristics of both austenitic and ferritic types of stainless steel tubing and pipe.

*Tubular Products Div.*
*The Babcock & Wilcox Co.*

**Circle 159 on postcard for more data**

**Helicopter Trim Control**

Bulletin on force gradient actuator for fine-tubing and holding helicopter attitude automatically.

*Airborne Accessories Corp.*

**Circle 160 on postcard for more data**

**Measuring & Recording Instruments**

Catalog on line of dynamic-measuring and recording instruments.

*Consolidated Electrodynamics Corp.*

**Circle 161 on postcard for more data**

**Silica Glass**

Bulletin describes Vycor brand 96 per cent silica glass withstanding high temperatures and drastic thermal shock.

*Corning Glass Works*

**Circle 162 on postcard for more data**

**Tooling Plastic**

Bulletin, "EPOCAST in the Foundry."

*Furane Plastics, Inc.*

**Circle 163 on postcard for more data**


WHEN "ULTRA-CLEANLINESS" IS "ULTRA-CRITICAL"...

...use Curtiss-Wright ULTRASONIC CLEANERS

Our engineers learned long ago, while perfecting their own critical aircraft parts cleaning operations, that building a good ultrasonic cleaner is a precision job that calls for the best in design thinking.

As a result, Curtiss-Wright has developed ultrasonic cleaning equipment with performance features not only important to production, but absolutely essential to the critical cleanliness demands of missile components:

- **Uniform cleaning action—no dead areas**
- **Complete flow control—immediately sweeps all loosened dirt out of the system so it cannot be redeposited on the parts**
- **Maximum usable power—shortens cleaning time**
- **Absolute filtering—easily interchangeable paper filter cartridges with sintered metal tramp filters**
- **Sealed lid design—lowers solvent loss**

*Whether you want to clean small or large parts, sub-assemblies or complete assemblies—whether you have a cleaning problem where speed and economic factors are important or wherein extreme cleanliness is the prime consideration, our engineers have the knowledge and experience to supply the equipment you need.*

WRITE FOR LITERATURE

PRINCETON DIVISION
CURTISS-WRIGHT
CORPORATION · PRINCETON, N.J.

In Canada contact CANADIAN CURTISS-WRIGHT LIMITED, 1980 SHERBROOKE STREET WEST, MONTREAL, P.Q., CANADA
In countries other than U.S.A. and Canada contact
EXPORT DIVISION, CURTISS-WRIGHT CORPORATION, 50 ROCKEFELLER PLAZA, NEW YORK 20, NEW YORK

# industry notes

## PROPELS POLARIS

High-strength steel alloy is used for this Polaris rocket motor casing. It is being fabricated in evaluation quantities at Temco Aircraft Corp.'s Dallas facilities under subcontract from Aerojet General Corp.

## LITTLE JOE R & D VEHICLE READIED

First two booster vehicles for Little Joe (to be used in the early phase of the Mercury manned satellite project) are ready for use at NASA's Wallops Island research station.

Built by North American Aviation, the booster - capsule combination is 44½ ft. long with maximum diam. of nearly 6½ ft. Booster is powered by four Castor and four Recruit solid propellant engines with accumulated thrust of approximately 372,000 lb.

NAA's Missile Division previously delivered Little Joe's rocket launcher. A special team built and delivered it in 4½ months.

## PROJECT MERCURY FINDS A VOICE

First prototype of Project Mercury's communications system is being delivered to McDonnell Aircraft Corp., prime contractor, by Collins Radio Co.

The system is designed to provide voice communications for the pilot during orbit; command functions within the capsule during launch, orbit, and re-entry; tracking and direction finding signals; and telemetry of scientific data.

## NEW CONCEPT PROVIDES FLIGHT & COMMAND DATA

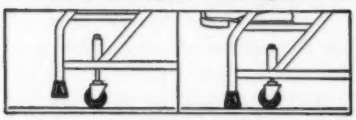
A direct optical view of the terrain below, integrated with flight situation or navigational data. . . .

This is the concept of "V.I.P.," (Visual Integrated Presentation), a new type of flight data display designed by Chicago Aerial Industries.

All types of electronic intelligence information may be shown in the central display area in various combinations, such as infra-red and radar, or with the direct view. Use of optical paths and image amplification from miniature cathode ray tubes provides "fail-safe" separate inputs for data.

BALLYMORE
Safety-Step LADDERS

PYRAMID DESIGN automatically centers the body, and automatically locks to the floor. An exclusive Ballymore design.



With and without handrails, all-welded construction... your choice of steel, or aluminum.

*For complete information, write:*
BALLYMORE COMPANY
WEST CHESTER 27, PA.

BALLYMORE
EQUIPMENT FOR ABOVE-FLOOR SAFETY

LOOK FOR THIS LABEL TO BE SURE IT'S THE BEST

Circle 38 on Inquiry Card


## CHECKING EINSTEIN . . .

Atomic clock being developed by Hughes Aircraft Co. under a $200,000 NASA contract will probably be sent into orbit in several years. It will check Einstein's general and special relativity. In the different gravitational field above Earth, it should apparently run at a different rate than a clock on the ground.

Time will be measured in the block by vibrations of ammonia molecules counted electronically.

## LIQUID HYDROGEN: PROMISING FUTURE

Air Force plant No. 74 is located in the Florida Everglades, not far from West Palm Beach.

It is believed the world's only large tonnage unit of its kind. Its product is liquid hydrogen. Burned in air or oxygen, hydrogen yields about twice the heat of combustion of its nearest competitor on a weight basis.

The production by Air Products, Inc., Allentown, Pa., is providing the large test and development quantities needed by the Air Research and Development Command. One possible application: nuclear rocket propellant.

Briefly, the manufacturing process is this. Oil molecules yield hydrogen directly (about two thirds of their atoms being hydrogen atoms). $H_2$ is also recovered from water as steam. This process, eliminating much carbon monoxide impurity, is called a two-stage "steam shift" reaction. The CO and steam are converted catalytically into $CO_2$ and hydrogen. $CO_2$ is then removed by scrubbing with monoethanolamine. The gas is later purified into hydrogen 99.99999 per cent pure, deeply refrigerated, subcooled below liquefaction temperature and stored in insulated tankage.

STRUCTURES ENGINEERS

Exceptional opportunities are available for Structures Engineers on our B-70 and F-108 weapon systems and X-15 manned space aircraft.

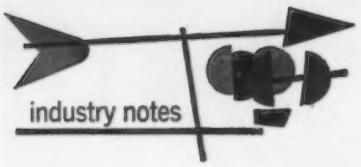
*Stress Analysis*—Rigorous design requirements necessitate extensive structural investigation of the influence of high temperatures and unconventional external loadings. Stress engineers concerned with such structures will have the opportunity to utilize their technical knowledge to the fullest extent in the development of new analysis methods.

*Load Analysis*—Corresponding demands on the structural loads engineer have also created unique careers with significant potential in the fields of dynamic loads, aeroelastic loads, loading spectra, flight load data analysis, and digital and analog computer programming.

*Weight Analysis*—Exacting air vehicle performance requires the optimization of structural design layouts to produce the lightest weight configurations. Weight engineers with experience in stress analysis are required for the formulation of advanced weight estimation and control procedures.

For details about these positions please write: Mr. L. H. Stevenson, Engineering Personnel, North American Aviation, Inc., Los Angeles 45, California.

THE LOS ANGELES DIVISION OF
NORTH AMERICAN AVIATION, INC.




# TERRA-SCOPE

## CONTRACTS . . .

The Army awarded Raytheon Co. approximately $61-million in new contracts for the Hawk missile system. The Hawk will also be produced in Europe under a coordinated program of Belgium, France, The Federal Republic of Germany, Italy, and The Netherlands.

Sperry Rand Corp.'s Utah Engineering Laboratory received $17.8-million from Army Ordnance for production and continued development of Sergeant; $14.3-million for the missile system's field equipment.

The Navy announced $10-million in contracts to Sylvania Electric Products, Inc., for developing communications systems for the Polaris program. The Army awarded Western Electric Co. $60,159,214 for continued work on Nike-Hercules.

The Air Force awarded $24,746,315 to Avco Corp.'s Lycoming Div. for both helicopter and turboprop versions of T53 gas turbines. The Air Force awarded Bell Helicopter Corp. $500,000 for advance development on the Army's HU-1 jet helicopter using the Lycoming T-53-L5. Chance Vought received $25.6-million from the Navy for F8U-2N airplanes and equipment.

Vertol Aircraft Corp. received an initial $6-million contract for design and development of five "Chinook" YHC-1B transport helicopters.

In Research and Development, the House Committee on Science and Astronautics announced a special study to understand the R & D contracts and contract procedures of NASA, the National Bureau of Standards, and the National Science Foundation.

"ASTOR," a new submarine weapons system being developed for the Navy by Westinghouse Electric's Ordnance Dept., is an electric torpedo measuring almost 20 ft., weighing over one ton, with longest range yet against submarine and surface vessels.

•

Douglas Aircraft plans to have its DC-9 jet transport operating by early 1963. The airliner will use four Pratt & Whitney JTF-10 turbofans as the initial or primary powerplants.

•

Concept of an unmanned remote-controlled missile-helicopter for fighting fire from plane crashes has been developed by engineers at Solar Aircraft Co. The "Firefly," shot from launcher by solid propellant rocket, would glide at 1,000 ft. as fixed wing craft. At fire site, three rotor blades in tail would be unlocked for helicopter action. Tiny rocket motors in each rotor blade tip furnish power for hovering. Extinguisher in nose is operated by remote control. The 5,000 lb 16-ft. long vehicle could reportedly be built by perfecting existing systems.

•

Boeing has completed a year-long simulated flight test program on the B-52G's fuel system. Tests proved out the theory of the single manifold fuel system, the "override" method in which all fuel pumps are turned on simultaneously and center (or fuselage) tanks are emptied first.

•

Wright Air Development Center's findings on best body positions forward accelerations during a three stage rocket flight into orbit: head and trunk tilted 25 deg forward, legs sharply bent.

L. B. Smith Aircraft Corp. will turn out first of its executive versions of the Douglas B26 next month. Smith will produce both pressurized and non-pressurized models as the "Tempo."

•

NASA has adopted existing Department of Defense regulations on industrial security. Agreement between the two authorizes DOD to act on behalf of NASA. This includes security clearances to employees of NASA contractors, and inspection of contractor facilities and operations.

•

New speed record for a dual rail vehicle—2,075 mph—was attained by rocket sled at Edward's AFB. Sled, designed by Air Force engineers was propelled by Thiokol's "Recruit" solid propellant rocket engine. Two vertical wedges, tied together by a cross member, helped overcome "aerodynamic choking" from air compression between the underbody and the ground.

•

Boeing has speeded up the milling of multi-bladed turbine wheels more than 40 times. Special hydraulic controls, and a rotational feature, added to a self-guided milling machine, allow production in one operation. Formerly the production required one step to produce the wheels with flat blades; a second process to attain the slightly-curved blade shapes.

•

"Bristol" and "Armstrong Siddeley" will no longer identify engines in production. Because they have merged into Bristol Siddeley Engines Ltd., all engines still produced by Bristol Aero-Engines and Armstrong Siddeley Motors will be designated Bristol Siddeley.

New series of **coatings on polyurethane basis** is being produced by Columbia Technical Corp., Woodside, N. Y., for solderable humidity-proofing in electronic applications.

The B-58 Hustler has **Metalset A2 caulking compound,** which is based on "Bakelite" epoxy resins, as smooth surface between fuselage and wing templates. The epoxy is formulated with atomized aluminum, and hardened at room temp into tough caulking. Manufacturer is Smooth-on Mfg. Co., Jersey City, N. J.

A new protective coating is being marketed to **seal metal and stainless steel surfaces** against biting and cleaning effects of pickling and passivating. Developer: Consolidated American Services, Inc., Culver City, Calif.

The Air Force's RC-121D early warning planes, produced by Lockheed at Burbank, now include wing tip fuel tanks protected against lightning by **rubber-coated nylon blankets** produced by B. F. Goodrich Aviation Products. Six static-conducting fin-like strips extend lengthwise on the tank. Long pointed probes at each end of the tank also serve as lightning arrestors.

**Forgeable sintered tungsten and tungsten alloy billets and preformed shapes** are being produced by Firth Sterling, Pittsburgh. Firm plans to install equipment for producing pure tungsten ingots 10 in. diam., 20 in. long, 1100 lb. in weight.

Vacuum "plating" process deposits **corrosion-resistant coating of pure aluminum** on a wide range of base metals from high tensile and mild steels to aluminum die casting alloys. Developed by the research division of National Research Corp., the ductile, non-porous coatings may be anodized to provide excellent wear resistance, and may have large-volume applications for aircraft and missile parts.

**Rubber and asbestos material** for the Navy Bureau of Ordnance by Astrodyne Corp. reportedly has advantages over reinforced plastic for insulation of solid fuel rocket motors. Burning time is said to be extended three or four times.

Corning Glass Works is seeking a **high-strength mounting device** for its Pyroceram missile radomes. The mounting material must withstand higher temperatures and greater aerodynamic loads for increased missile speeds.

Martin Co. and Nuclear Metals, Inc., announced they have solved the problem of **brittleness in beryllium forms,** and have developed beryllium sheet material homogeneous enough for structural fabrication.

BARCO

**Flexible Joints for Handling Liquid Oxygen and other missile fuels**

BARCO has the *specially designed* flexible joint which has passed the official "Qualification Test":

—Used in piping on fueling lines handling liquid oxygen, JP4 and JP5 fuel, white and red fuming nitric acid, and other chemicals.

—Provides swivel motion to allow for thermal expansion and contraction.

—High corrosion resistance. Other special designs available. For temperatures from −320°F. to +1,000°F., and higher. Also joints for gas and hydraulic service.

Patent Pending

(Right) 6"—180° Flanged Barco Flexible Joint for use in fueling line handling liquid propellant. Also straight and 90° designs.

AIRCRAFT DIVISION

**BARCO** *Serving Industry Since 1908*
**MANUFACTURING CO.,** 565J Hough St., Barrington, Illinois
Circle 40 on Inquiry Card

*Electrolytic Metal Removal*

**Potential Unlimited**

This new procedure has solved hitherto unsolvable problems, and greatly increased capacity and quality in virtually every application.

As pioneers in this very "young" development, we can offer you real help in licking hard metal removal problems, with actual installation and performance data. **WRITE TODAY!**

*Results depend on the spindle used.* There is nothing finer in its field than a STANDARD Super Precision Spindle . . . available for electrolytic application in 50 to 3000 Amperes.

THE **STANDARD** ELECTRICAL TOOL CO.
Precision Spindle Division
3000 River Road, Cincinnati 4, Ohio
Circle 41 on Inquiry Card

# LATCHES

*outstandingly different*

- over-the center positive action
- flush when closed
- seals against internal and external pressure
- protects against dirt and moisture
- fail-safe construction
- aromatic fuel resistant
- 1 to 1-¾ oz. weight

Missile-Air latches are in use on jet aircraft, missiles and electronic equipment under the most severe environmental conditions. They cannot fail under stress or vibration. Fingertip opening or closing without tools greatly speeds servicing. *Sensibly priced for any application.* Many types to choose from or special design on request.

**Send for complete technical information to:**
**1700 Rosecrans Avenue,**
**Manhattan Beach, California.**

*Missile-Air*

U S C M

**A Division of United States Chemical Milling Corporation.**

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## industry notes

### FACILITIES . . .

**Celanese Corp. of America** is acquiring a plant in Asheville, N. C., for development and eventual production of high energy chemical fuel. The plant had belonged to Oerlikon Corp., Zurich. It will be fully American owned and operated by **Amcel Propulsion, Inc.**, in which Celanese will have a controlling interest. Facilities will include a test firing range and R & D laboratories.

A new missile systems test facility will be built at **Redstone Arsenal** for testing solid propellant motors for Pershing.

**Vernitron Corp.** has been formed in Torrance, Calif., for the design, development, and production of servo components.

**Rockwell-Standard Corp.** has acquired **Air-Maze Corp.**, filter manufacturers.

**The Tapco Group West Coast Div. Thompson Ramo Wooldridge, Inc.**, will construct a $2 million aircraft and missile components plant in Orange County, Calif.

**Chicago Aerial Industries** has acquired a new 8,000 sq. ft. office location at Melrose Park, Ill. Next year it will build a new engineering and production facility near Barrington, Ill.

First space-environment chamber capable of taking a human 150 miles above the earth into a simulated ionosphere, will be built by **Tenney Engineering Inc.**, Union, N. J. and installed in Republic Aviation's astronautics research center early in 1960.

**National Semiconductor Corp.** has been formed to specialize in development and manufacture of high quality semiconductor devices. Location: Danbury, Conn.

New **Chemical Milling International Corp.**, Los Angeles, will engage in the production, consulting, and research of chemical milling.

**Aerojet-General Corp.** has established a Space Technology Div.

**DO YOU NEED PARTS REQUIRING FINE MACHINE WORK SUCH AS THIS FACE CLUTCH?**

ACTUAL SIZE

**SPECIFICATIONS:**
Material: Type # 303 Stainless Steel
300 90° "V" teeth, equally spaced
Teeth .0092-.0005 deep
Face runout of top of teeth not to exceed .0005TIR
Completely burr free

This is the class of work which has been the specialty of LaVezzi for over 50 years. Your critical machine parts can be produced efficiently and correctly by LaVezzi, and your quote requests are eagerly solicited. Facilities list and brochure upon request.

*LaVezzi* **MACHINE WORKS**

4635 WEST LAKE ST., CHICAGO, ILLINOIS

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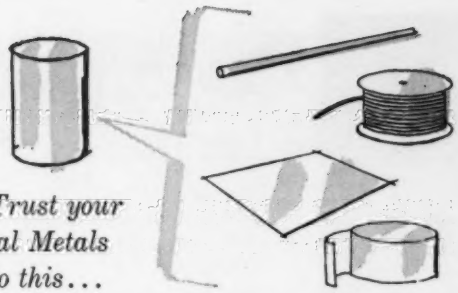

*Trust your Special Metals to this...*

## pioneer converter

Corporations use Johnston & Funk as an extension of their own development facilities — as a fast, highly reliable converter of reactive metals, super alloys, special steel and non-ferrous alloys.

Under close, constant supervision by trained metallurgists, J&F will break down your ingots into billets, wire, small diameter bars, rod, narrow strip, foil, special shapes. Services also include straightening, winding, grinding, cutting, vacuum annealing and pickling.

As a pioneer converter *and* producer of commercial and research grades, J&F offers you fast, flexible service, a degree of quality unobtainable from conventional sources. *Write for facilities brochure and prices, or arrange to meet one of our metallurgists.*

**Johnston & Funk**
METALLURGICAL CORPORATION
WEST KEMROW AVENUE, WOOSTER, OHIO

*A subsidiary of Mallory-Sharon Metals Corporation*

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## THE NEW TITAN *"TitanSert"* THREADED INSERT or BUSHING DRIVER

**. . . featuring primary and automatic secondary clutches for driving either self-tapping or regular inserts.**

Drives inserts to a very accurate position. Selective position is accomplished by a wide-range depth gage on the driver while driver is rotating. Depth gage is ball bearing mounted, eliminating marking of casting face. "TitanSert" has a primary clutch for driving and a secondary positive clutch for reversing out of insert after it is driven. When insert is driven to proper position, the primary (drive) clutch disengages. When the motive power is pulled back to actuate the automatic reverse, the secondary clutch engages and the "TitanSert" rapidly reverses out of the predriven insert. "TitanSert" can easily be used with a tapping head mounted on an ordinary drill press; or with automatic air or electric tapping motors when provision is made to keep the tool spindle at right angles to face of casting.

Sizes available: No. 1, Cap. No. 10 to ⅜" I.D.; No. 2, Cap. ⅜" to ½" I.D.

***Write for details and prices today!***

TITAN TOOLS
World's Largest Producers Of Stud Drivers And Pullers
**TITAN TOOL CO.**
48 MAIN ST., FAIRVIEW (ERIE COUNTY), PA.

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## Just One Squeeze with IDEAL's New "Custom Stripmaster" Removes Teflon* and Other Hard-to-Strip Insulations

***To help prevent wire nicking and insulation damage, these new IDEAL "Custom Stripmasters" are precision drilled on watchmaker's equipment.***

With Ideal's new Custom Stripmasters, a light squeeze on the handles strips any wire completely clean and bare up to a full ⅞ inch.

To help prevent nicking and scraping of wires, the Custom Stripmaster's matched sets of blades are precision drilled on watchmaker's equipment to the exact wire sizes. Counterbored blades ride on cut insulation to prevent scratching of stripped wire. Jaws grip wire firmly to prevent insulation damage. 3 models available. Wire sizes from No. 10 to 30.

*Reg. Trademark of DUPONT

Custom Stripmaster® Patented, No. 2,523,936 by IDEAL

IDEAL INDUSTRIES, Inc.
[illegible] Park Ave. [illegible], Ill.

Gentlemen: Please send catalog information on IDEAL's New "Custom Stripmaster."

Name_____
Company_____
Address_____
City_____ Zone____ State_____

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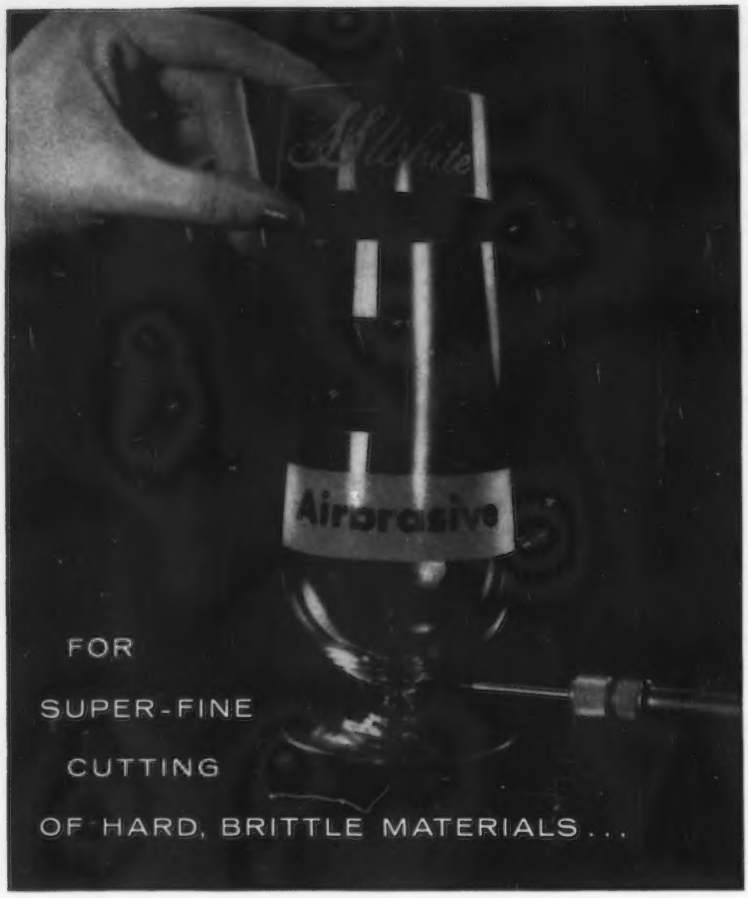



THE S. Silbhite Industrial Airbrasive® Unit

Not that we advise doing this to your fine crystal glassware, but it seemed to us a dramatic way to show you the versatility and the cool, shockless cutting and frosting action of our Industrial Airbrasive Unit.

Cuts as fine as .008" or large frosted areas are equally easy to make with this amazing industrial tool. A gas-propelled stream of abrasive particles quickly slices or abrades, as needed, almost any hard, brittle material, such as fragile crystals, glass, oxides, metal, minerals, ceramics.

Applications range from printed circuits, wire-stripping potentiometer coils, and cleaning off oxides... to shaping or drilling germanium. Every day new uses for the Airbrasive Unit are being discovered.

*Send us your most difficult samples and we will test them for you.*

**SEND FOR BULLETIN 5705A... complete information.**

1064

New dual Model DI

S. Silbhite®

S. S. White Industrial Division
Dept. 18A, 10 East 40th Street, New York 16, N. Y.
Western Office: 1839 West Pico Boulevard, Los Angeles 6, California

## industry notes

An Advanced Technical Planning Div is operating at **All American Engineering Co.**, Wilmington, Del., to consolidate aero-space research and development activities.

**Singer Manufacturing Co.** has formed a Special Products Div. It will include the Diehl Mfg. Co., Haller, Raymond and Brown Inc., and Singer's Military Products Div.

**Superior Tube Co.**, Norristown, Pa., is opening a new office building and factory near Phila., for processing tubing from the new reactive metals.

**Wall Tube & Metal Products Co.**, Newport, Tenn., has acquired a second factory building.

**Engelhard Industries** has opened a new million-dollar research and development laboratory in Newark, N. J.

**Kearfott Co., Inc.** subsidiary of General Precision Equipment Corp., has expanded its plant facilities in Asheville, N. C. by 82,500 sq. ft.

**Norton Co.**, Worcester, Mass., has purchased the inventories, machinery and equipment with drawings, designs and certain other assets of **Gould & Eberhardt, Inc.**, Irvington, N. J.

**Century Electronics & Instruments, Inc.**, Tulsa, Okla., has formed a new ground support equipment and test instrument division.

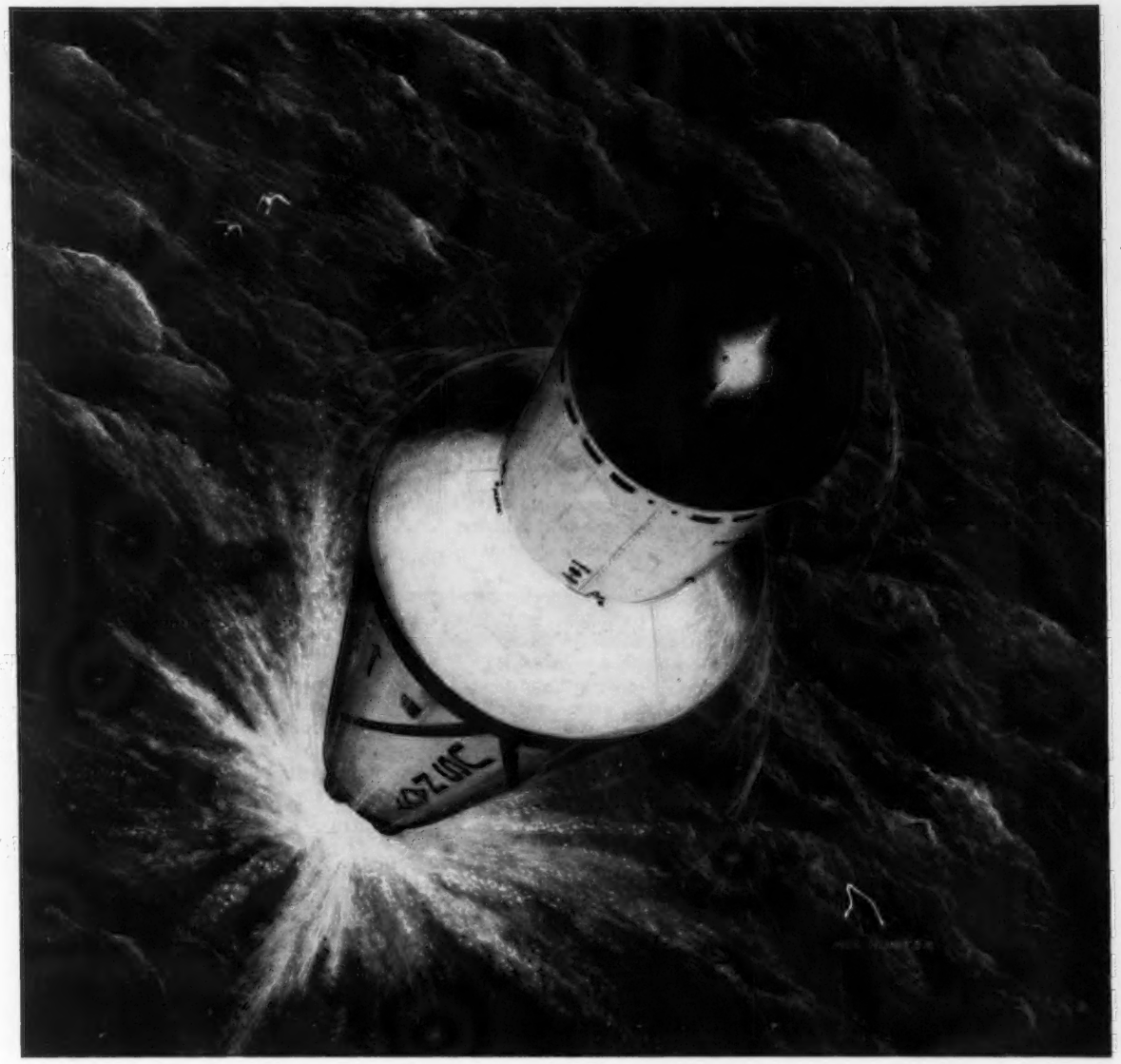
**Applied Research Laboratories, Inc.**, Glendale, Calif. has formed an Aero-Space Div. for manufacture of airborne and ground support equipment.

**Universal-Cyclops Steel Corp.** is opening a new stainless steel strip plant at Coshocton, O., with capacity of 20,000 tons per year.

**The Warner & Swasey Co.**, Cleveland, is building a 40,000 sq ft research facility in Solon, O.

**Permanent Filter Corp.** is building a new $1¼-million manufacturing and research plant in Oxnard, Calif.

**Philco Corp.** will build a Transac computer center on a 72-acre tract of land near Willow Grove, Pa.



*Project:* **SALT WATER PUNCH**

*Filter Application:* **PROTECT HYDRAULIC CONTROLS**

*Filter:* **PUROLATOR**

The Polaris and the nuclear powered submarines which will carry and launch it form a mobile striking force that commands respect. Wherever they may be, it is imperative that, when the signal is given, the Polaris takes off and goes straight to the target.

Hydraulic control circuits play an important role in the programmed flight of the Polaris. To insure against malfunctions in the circuits, Purolator filters are designed as an integral part of many of them, to specifications set by Lockheed Missiles and Space Division, Polaris missile system manager.

Purolator engineers will gladly bring to your needs the filtration knowledge they provide for Polaris and other top-priority projects. A letter or phone call describing your aircraft or missile filtration requirements will receive prompt attention.

*Filtration For Every Known Fluid*

**PUROLATOR**

**PRODUCTS, INC.**

RAHWAY, NEW JERSEY AND TORONTO, ONTARIO, CANADA

**august 3-5**
annual meeting
association of the u.s. army
sheraton-park hotel, washington, d.c.

◆

**august 5-7**
western regional meeting
american astronautical society
ambassador hotel, los angeles

◆

**august 5-7**
conference on problems of hypersonic
and space flight
stanford university, stanford, calif.

**august 9-12**
heat transfer conference
american society of mechanical
engineers, american institute
of chemical engineers
university of connecticut, storrs, conn.

◆

**august 12-14**
conference on x-ray analysis
denver research institute
stanley hotel, estes park, colo.

◆

**august 17**
national ultrasonics symposium
institute of radio engineers
stanford university, stanford, calif.

◆

**august 18-21**
western electronic show
and convention
institute of radio engineers
cow palace, san francisco

◆

**august 24-26**
gas dynamics symposium
american rocket society
northwestern university, evanston, ill.

◆

**august 27-28**
International commonwealth
spaceflight symposium
church house, westminster, london

◆

**august 31-september 2**
army-navy instrumentation program
and industry briefing
statler hilton, dallas, tex.

◆

**august 31-september 5**
10th annual congress
international astronautical federation
church house, westminster, london

◆

**september 1-2**
conference on physical chemistry
in aerodynamic and space flight
OSR (air force), MSVD (general elec.)
university of pennsylvania, phila., pa.

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| MODEL NO. | MAX. INLET PSI | MAX. OUTLET PSI | FEATURES | MAX. FLOW SCFM |
|---|---|---|---|---|
| GD10 | 3,600 | 500 | Single adjustment regulator control | 250 |
| GD30 | 2,500 | 2,500 | Load & bleed valve control | 400 |
| GD31 | 3,600 | 3,600 | Load & bleed valve control | 600 |
| GD61C | 2,500 | 2,500 | Load & bleed valve control | 170 |
| GD62C | 3,600 | 3,600 | Load & bleed valve control | 200 |
| GD65 | 6,000 | 6,000 | Load & bleed valve control | 250 |
| GD65C | 7,000 | 7,000 | Load & bleed valve control | 250 |
| GD80A | 5,000 | 5,000 | Load & bleed valve control | 500 |
| GD81A | 10,000 | 10,000 | Load & bleed valve control | 800 |
| GD86R | 10,000 | 10,000 | For remote control only | 1,200 |
| GD100R | 6,000 | 6,000 | For remote control only | 20,000 |
| GD100 | 6,000 | 6,000 | Load & bleed valve control | 20,000 |
| GD200 | 6,000 | 6,000 | Load & bleed valve control | 50,000 |
| GD700 | 7,000 | 7,000 | Single adjustment regulator control; self relieving | 250 |
| SR10 | 3,600 | 1,000 | Small, spring loaded regulator | 4 |
| LR20B | 7,000 | 7,000 | Spring loaded regulator; self relieving | 2 |
| LR20BSS | 10,000 | 10,000 | Spring loaded; stainless steel | 2 |
| LV10 | 7,000 | 7,000 | Loader valve control | 15 |
| BPR10 | 7,000 | 7,000 | Back pressure regulator | 2 |

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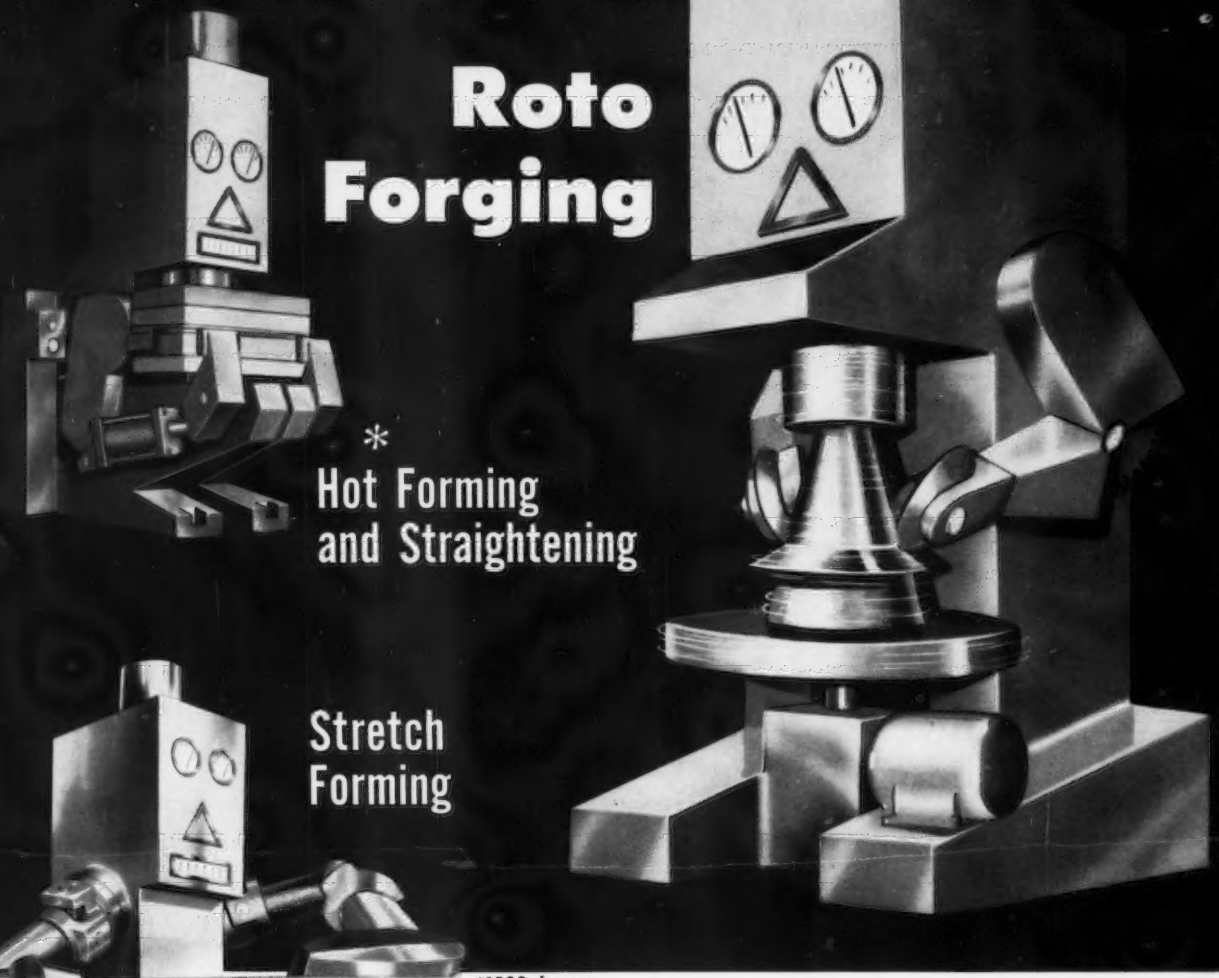

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